VERIFICATION OF TRANSLATION

I, the below named translator, hereby declare:

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that I am knowledgeable in the English and Japanese languages and that I believe the following is a true and complete translation into the English language of Japanese Patent Application No. 2000-309813 filed in the Japanese Patent Office on the 10th day of October 2000 for Letters Patent.

Signed this 26th day of October 2005

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[TITLE OF THE DOCUMENT] Patent Application

[REFERENCE NUMBER] 33509773

[DATE OF FILING] October 10, 2000

[ADDRESS] To Commissioner of the Japanese Patent Office

[INTERNATIONAL CLASSIFICATION] H04L 12/00

[TITLE OF THE INVENTION] Packet Communication Method and System

[THE NUMBER OF CLAIMS] 16

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[DOCUMENTS ATTACHED]
Specification 1 set
Drawings 1 set
Abstract 1 set
General Power of Attorney No. 9709418

[TITLE OF THE DOCUMENT]

Specification

[TITLE OF THE INVENTION]

Packet Communication Method and System

[PATENT CLAIMS]

[Claim 1]

A method of packet communication to be used in a communications network comprising a plurality of buses each including at least one node and being connected to each other via a plurality of bridges, wherein said bridges are connected between different buses and perform operation under a standardized serial bus communication protocol, characterized in that, when two or more nodes that are interconnected via said bridges communicate with each other within a shared multicast group, said bridges connect channels of said different buses.

[Claim 2]

A method of packet communication to be used in a communications network comprising a plurality of buses each including at least one node and being connected to each other via a plurality of bridges, said buses and said bridges performing operation under a standardized serial bus communication protocol, characterized in that:

a) each of said nodes that initiates a session on each of said buses is responsible for performing management of the channels to be used by its own multicast group for transmission of packets, and broadcasts a message identifying the relationship between multicast groups and said channels; and

b) each of said bridges is responsive to receipt of said message identifying the same bus for establishing a connection between different channels according to the received message.

[Claim 3]

A method of packet communication to be used in a communications network comprising a plurality of buses each including at least one node and being connected to each other via a plurality of bridges, said buses and said bridges performing operation under a standardized serial bus communication protocol, characterized in that:

a) each of said nodes that initiates a session on each of said buses is responsible for performing management of the channels to be used by its own multicast group for transmission of packets, and broadcasts a message

identifying said multicast group and said channels; and

b) each of said bridges that is connected to a bus where no node participates in said multicast group is responsive to receipt of a plurality of said messages identifying a same multicast group for reserving a channel in said bus where no node participates in said multicast group for a multicast session.

[Claim 4]

A method of packet communication to be used in a communications network comprising a plurality of buses each including at least one node and being connected to each other via a plurality of bridges, said buses and said bridges performing operation under a standardized serial bus communication protocol, characterized in that:

a) each of said nodes that initiates a session on each of said buses is responsible for performing management of the channels to be used by its own multicast group for transmission of packets, and broadcasts a message identifying said multicast group and said channels;

b) each of said nodes that exclusively perform packet reception on each of said buses is responsible for performing management of channels to be used for receiving packets from multicast groups if there is no node within the same bus that performs channel management and broadcasts a message identifying said multicast group and said channels; and

c) each of said bridges is responsive to receipt of said message identifying the same bus for establishing a connection between different channels according to the received message.

[Claim 5]

A method of packet communication as claimed in claim 3, characterized in that one of the two or bridges that are connected to the bus where no node participates in the multicast group having a particular node identification number operates as a management node to initiate a channel reservation process with priority over other bridges.

[Claim 6]

A method of packet communication as claimed in any one of claims 2 to 5, characterized in that when said bridge receives a message identifying said multicast group and said channel:

a) performs a check to see if a channel is reserved for the identified multicast group within the bus identified by the received message, and determines whether a channel can be reserved or not if said check indicates

that there is no reserved channel; and

b) transfers said message if said check indicates that a channel is reserved for said multicast group, or if said determination indicates that a channel can be reserved.

[Claim 7]

A method of packet communication as claimed in any one of claims 2 to 6, characterized in that the node that stops transmission of packets to said multicast group restores the channel acquired for the multicast group to a specified node that functions as an isochronous resource manager, and that the bridge that stops transmission of information concerning said multicast group and said channel and is connected to said channel acquired for said multicast group disconnects said channel if none of said information is received from any of said buses.

[Claim 8]

A method of packet communication as claimed in any one of claims 2 to 7, characterized in that said standardized serial bus communication protocol is the protocol specified by the IEEE 1394 standard.

[Claim 9]

A packet communication apparatus for a communications network comprising a plurality of buses each including at least one node and being connected to each other via a plurality of bridges, wherein said buses and said bridges performs operation under a standardized serial bus communication protocol and said bridges are connected between different buses, characterized in that, when two or more nodes that are interconnected via said bridges communicate with each other within a shared multicast group, said bridges connect channels of said different buses.

[Claim 10]

A packet communication apparatus for a communications network comprising a plurality of buses each including at least one node and being connected to each other via a plurality of bridges, said buses and said bridges performing operation under a standardized serial bus communication protocol, characterized in that, when two or more nodes that are interconnected via said bridges communicate with each other within a shared multicast group, a channel is acquired for said multicast group on a directly connected bus and connect channels of said different buses.

[Claim 11]

A packet communication apparatus for a communications network comprising a plurality of buses each including at least one node and being connected to each other via a plurality of bridges, said buses and said bridges performing operation under a standardized serial bus communication protocol, characterized by:

a memory for storing channel mapping information indicating correlation between a plurality of multicast communication channels and said plurality of buses;

a packet analyzer for making a comparison between channel mapping information contained in a received message and said channel mapping information stored in said memory; and

a packet switching unit for forwarding the received message to said destination bus if a multicast communication channel is acquired in the destination bus of said received message or a new multicast communication channel can be acquired in said destination bus, and establishes a connection between channels indicated in said channel mapping information if the result of said comparison by said packet analyzer indicates that the destination address of the received message matches a stored address and a port number at which the message is received is different from a stored port number.

[Claim 12]

A packet communication apparatus for a communications network comprising a plurality of buses each including at least one node and being connected to each other via a plurality of bridges, said buses and said bridges performing operation under a standardized serial bus communication protocol, characterized by:

a memory for storing channel mapping information indicating correlation between a plurality of multicast communication channels and said plurality of buses;

a packet analyzer for making a comparison between channel mapping information contained in a received message and said channel mapping information stored in said memory and initiating a channel acquisition routine for acquiring a multicast communication channel on a bus where no management bus is present if result of said comparison indicates that the destination address of the message matches a stored address and said received message is not received from a receive node; and

a packet switching unit for forwarding the received message to said

destination bus if a multicast communication channel is acquired in the destination bus of said received message or a new multicast communication channel can be acquired in said destination bus, and establishes a connection between channels indicated in said channel mapping information if the result of said comparison by said packet analyzer indicates that the destination address of the received message matches a stored address and a port number at which the message is received is different from a stored port number.

[Claim 13]

A packet communication apparatus as claimed in claim 12, further characterized by a packet transmitter for transmitting an enquiry message for determining whether a management node is present on said destination bus when said packet switching unit initiates said channel acquisition routine.

[Claim 14]

A packet communication apparatus as claimed in claim 13, further characterized by a timer for timing a predetermined amount of time for accepting said enquiry message and in that said amount of time for each bridge is different from each other.

[Claim 15]

A packet communication apparatus for a communications network comprising a plurality of buses each including at least one node and being connected to each other via a plurality of bridges, said buses and said bridges performing operation under a standardized serial bus communication protocol, characterized by:

a packet analyzer for initiating a channel acquisition routine for acquiring a multicast communication channel on a bus if a bus identifier contained in the received message indicates a bus which is other than the bus to which the source node of the message belongs; and

a packet transmitter for transmitting an enquiry message for determining whether a multicast communication channel is acquired when said packet analyzer initiates said channel acquisition routine.

[Claim 16]

A packet communication apparatus as claimed in any one of claims 11 to 15, characterized in that said standardized serial bus communication protocol is the protocol specified by the IEEE 1394 standard.

[DETAILED DESCRIPTION OF THE INVENTION]

[0001]

[Technological Field of the Invention]

The present invention relates to a method of packet communication using a serial bus, such as IEEE 1394 serial bus, that controls hardware such as video cameras from a computer, and more particularly to a method packet communication for a plurality of nodes interconnected by bridges, using a protocol such as TCP (Transmission Control Protocol)/IP (Internet Protocol) .

[0002]

[Prior Art]

Attentions have recently been focused on the IEEE 1394-1995 standard or IEEE 1394a-2000 standard that is adapted for use with networks to which hardware such as video cameras is attached. The IP over IEEE 1394 protocol (RFC 2734) has been developed by the IETF (Internet Engineering Task Force) in order to support the Internet Protocol on the IEEE 1394 network. This protocol supports transmission and reception of unicast, multicast and broadcast packets on the IEEE 1394 network.

[0003]

When transmitting a unicast packet on the IP over IEEE-1394 protocol, the asynchronous packet of the IEEE 1394 standard is used and when transmitting a multicast or a broadcast packet the asynchronous stream channel of the IEEE 1394 standard is used.

Further, the IP over IEEE-1394 protocol specifies a protocol called MCAP (Multicast Channel Allocation Protocol) for allocating an asynchronous stream channel to a multicast session within a bus.

[0004]

The following is a description of the MCAP protocol with reference to Figs. 11 and 12.

In Fig. 11, there is shown a bus to which an IP over IEEE 1394 capable node is attached. Fig. 12 shows a procedure for allocating a multicast channel to the node of Fig. 11. According to the IP over IEEE-1394 protocol, the source node 101 sends an enquiry broadcast message (procedure S201) to determine if a multicast channel for a multicast group has already been assigned.

[0005]

If no response message is returned following the transmission of the enquiry broadcast message of step S201, the source node 101 acquires a new channel from the IRM (Isochronous Resource Manager) node 102 that performs management of bus channels specified by the IEEE 1394 standard (procedure

S202), and broadcasts a report message containing information that indicates the mapping of the assigned channel identifier to the multicast group identifier (procedure S203). The channel management node 101 thereafter broadcasts the channel-multicast group mapping message at regular intervals. Once a multicast channel is assigned, the node 101 sends a multicast packet over the assigned channel (procedure S204).

[0006]

Next, when another node 103 initiates transmission or reception of a multicast packet, the node broadcasts an enquiry message in the same manner as the node 101 does when it inquires about a multicast channel (procedure S205). In this case, the channel management node 101, on receiving such an enquiry message, sends a reply message containing the mapping information just described above (procedure S206).

[0007]

Any of the nodes wishing to participate in the activity of this multicast group receives channel mapping information broadcast at regular intervals from the node 101 and performs transmission of a packet to the multicast group by referring to the channel indicated in the mapping information (procedure S207). Following the transmission of the packet to the multicast group, the node 101 returns the channel number obtained by procedure 202 to the IRM node 102. Now, the channel identified by the returned channel number is open to use.

[0008]

Referring next to Fig. 13 to describe the operation of the system when the node 101 returns the channel to the node 102.

Fig. 13 shows the operation of the node 101 when it returns the right to use of the a channel to the node 102 to free the channel for use by other nodes. First, the node 101 which functions as a management node of the channel broadcasts a message indicating the restoration of the right-to-use of a channel and the channel mapping information (procedure 301) when the node 1 terminates the transmission of a packet to the multicast group. If no node appears that takes over the right-to-use of the channel within a preselected time interval in response to the issuance of the restoration message, the node 101 returns the right-to-use of the channel to the ISM node 102 (procedure 302) and terminates the transmission of packets to the multicast group.

[0009]

[Problems to be Solved by the Invention]

A technique known as IEEE 1394 bridge (henceforth simply bridge) which is currently under study by P1394.1 is intended to segment a network that is compliant to the IEEE 1394 standard into a plurality of groups. Fig. 14 shows one example of IEEE 1394 network that is segmented by bridges 408. In this example network, buses 409 and 410 are interconnected by a bridge 407 and buses 410 and 411 are interconnected by a bridge 408. These bridges 407 and 408 segment a plurality of nodes attached to the IEEE 1394 network into two or more buses and each of these buses performs a bus reset isolation function and a communication function between the buses using a unicast asynchronous packet and a broadcast asynchronous stream packet.

[0010]

While the prior art bridges are capable of transferring a unicast asynchronous packet and a broadcast packet across multiple buses, they are not capable of transferring isochronous stream packets and asynchronous stream packets which are used in modes other than broadcast mode.

[0011]

As a result, if the node 401 on bus 409 and the node 403 on bus 410 acquire the right to use channels C1 and C2 (not shown) using the prior art procedure in an IEEE 1394 network of Fig. 14, for example, and start an IP multicast communications, the bridge 407 cannot transfer multicast packets between the channels C1 and C2. Therefore, multicast packets transmitted from the node 401 can only be received by the nodes on bus 409 and hence no inter-bus multicast packet transmission is possible.

[0012]

Furthermore, in the network of Fig . 14, if multicast channel is acquired between the buses 409 and 411 using the prior art procedure and if the bridges 407 and 408 are capable of transferring asynchronous stream packets, no packet transfer is possible between the buses 409 and 411 if no multicast channel is provided in advance in the intermediate bus 410.

[0013]

In addition, with the prior art procedure, the nodes that can acquire a channel for a multicast group is limited to the nodes that can transmit packets to the multicast group and hence the nodes that can only receive multicast packets cannot acquire a channel for multicast transmission. In the network of Fig. 14, for example, if the bus 409 has a node that can transmit a multicast

packet and if the bus 410 has only nodes that receive packets, the bus 410 is incapable of acquiring a channel for a multicast group. As a result, even if the bridge 407 is capable of transmitting asynchronous stream packets, multicast packets cannot be transferred between the buses 409 and 410.

[0014]

The present invention is based on the recognition of the above mentioned problem and has for its first object the provision of a packet communication method and apparatus capable of transferring multicast packets for a multicast group across a plurality of buses which are interconnected by bridges.

The present invention has for its second object the provision of a packet communication method and apparatus capable of transferring multicast packets for a multicast group across a plurality of buses which are interconnected by bridges even if there is a bus in the path of communication in which bus no channel is acquired.

Furthermore, the present invention has for its third object the provision of a packet communication method and apparatus capable of transferring multicast packets for a multicast group across a plurality of buses which are interconnected by bridges even if all nodes of a bus in the path of communication are receive-only nodes.

[0015]

[Means for Solving the Problems]

In order to solve the above mentioned problems, the present invention is characterized in claim 1 that, in a method of packet communication to be used in a communications network which comprises a plurality of buses each including at least one node and being connected to each other via a plurality of bridges, and wherein the bridges perform operation under a standardized serial bus communication protocol, when two or more nodes that are interconnected via said bridges communicate with each other within a shared multicast group, the bridges connect channels of said different buses.

According to claim 2 of the present invention, in the method of packet communication to be used in a communications network comprising a plurality of buses each including at least one node and being connected to each other via a plurality of bridges, said buses and said bridges performing operation under a standardized serial bus communication protocol, the invention is characterized in that (a) each of said nodes that initiates a session on each of said buses is

responsible for performing management of the channels to be used by its own multicast group for transmission of packets, and broadcasts a message identifying said multicast group and said channels, and (b) each of said bridges is responsive to receipt of said message identifying the same bus for establishing a connection between different channels according to the received message.

If there are two buses are available in each of which a channel is acquired for a multicast group and used for transmitting a multicast packet, the bridges interconnecting such buses perform mapping of the channels to the buses for transferring the packets.

[0016]

According to claim 3 of the present invention, in the method of packet communication to be used in a communications network comprising a plurality of buses each including at least one node and being connected to each other via a plurality of bridges, said buses and said bridges performing operation under a standardized serial bus communication protocol, the present invention is characterized in that (a) each of said nodes that initiates a session on each of said buses is responsible for performing management of the channels to be used by its own multicast group for transmission of packets, and broadcasts a message identifying said multicast group and said channels, and (b) each of said bridges that is connected to a bus where no node participates in said multicast group is responsive to receipt of a plurality of said messages identifying a same multicast group for reserving a channel in said bus where no node participates in said multicast group for a multicast session.

If no multicast channel is acquired in a bus that forms part of the communication path of a multicast communication, the bridges connected to such a bus automatically acquires a multicast channel to enable exchanging packets.

[0017]

According to claim 4 of the present invention, in the method of packet communication to be used in a communications network comprising a plurality of buses each including at least one node and being connected to each other via a plurality of bridges, said buses and said bridges performing operation under a standardized serial bus communication protocol, the present invention is characterized in that (a) each of said nodes that initiates a session on each of said buses is responsible for performing management of the channels to be used

by its own multicast group for transmission of packets, and broadcasts a message identifying said multicast group and said channels, (b) each of said nodes that exclusively perform packet reception on each of said buses is responsible for performing management of channels to be used for receiving packets from multicast groups if there is no node within the same bus that performs channel management and broadcasts a message identifying said multicast group and said channels, and (c) each of said bridges is responsive to receipt of said message identifying the same bus for establishing a connection between different channels according to the received message.

In a bus where the nodes attached to the bus are receive-only nodes, a receive-only node acquires a multicast channel on its own accord to enable packet exchange.

[0018]

According to claim 5 of the present invention, in the method of packet communication as claimed in claim 3, the present invention is characterized in that one of the two or bridges that are connected to the bus where no node participates in the multicast group having a particular node identification number operates as a management node to initiate a channel reservation process with priority over other bridges.

In a bus where there is no node that participates in the multicast group, duplicated acquisition of channels is prevented.

[0019]

According to claim 6 of the present invention, in the method of packet communication as claimed in any one of claims 2 to 5, the present invention is characterized in that when said bridge receives a message identifying said multicast group and said channel (a) performs a check to see if a channel is reserved for the identified multicast group within the bus identified by the received message, and determines whether a channel can be reserved or not if said check indicates that there is no reserved channel, and (b) transfers said message if said check indicates that a channel is reserved for said multicast group, or if said determination indicates that a channel can be reserved.

[0020]

According to claim 7 of the present invention, in the method of packet communication as claimed in any one of claims 2 to 6, the present invention is characterized in that the node that stops transmission of packets to said multicast group restores the channel acquired for the multicast group to a

specified node that functions as an isochronous resource manager, and that the bridge that stops transmission of information concerning said multicast group and said channel and is connected to said channel acquired for said multicast group disconnects said channel if none of said information is received from any of said buses.

According to claim 8, in the method of packet communication as claimed in any one of claims 2 to 7, the present invention is characterized in that said standardized serial bus communication protocol is the protocol specified by the IEEE 1394 standard.

According to claim 9, in the packet communication apparatus for a communications network comprising a plurality of buses each including at least one node and being connected to each other via a plurality of bridges, wherein said buses and said bridges performs operation under a standardized serial bus communication protocol and said bridges are connected between different buses, the present invention is characterized in that, when two or more nodes that are interconnected via said bridges communicate with each other within a shared multicast group, said bridges connect channels of said different buses.

According to claim 10, in the packet communication apparatus for a communications network comprising a plurality of buses each including at least one node and being connected to each other via a plurality of bridges, said buses and said bridges performing operation under a standardized serial bus communication protocol, the present invention is characterized in that, when two or more nodes that are interconnected via said bridges communicate with each other within a shared multicast group, a channel is acquired for said multicast group on a directly connected bus and connect channels of said different buses.

[0021]

According to claim 11, in the packet communication apparatus for a communications network comprising a plurality of buses each including at least one node and being connected to each other via a plurality of bridges, said buses and said bridges performing operation under a standardized serial bus communication protocol, the present invention is characterized by a memory for storing channel mapping information indicating correlation between a plurality of multicast communication channels and said plurality of buses, a packet analyzer for making a comparison between channel mapping information contained in a received message and said channel mapping

information stored in said memory, and a packet switching unit for forwarding the received message to said destination bus if a multicast communication channel is acquired in the destination bus of said received message or a new multicast communication channel can be acquired in said destination bus, and establishes a connection between channels indicated in said channel mapping information if the result of said comparison by said packet analyzer indicates that the destination address of the received message matches a stored address and a port number at which the message is received is different from a stored port number.

[0022]

According to claim 12, in the packet communication apparatus for a communications network comprising a plurality of buses each including at least one node and being connected to each other via a plurality of bridges, said buses and said bridges performing operation under a standardized serial bus communication protocol, the present invention is characterized by a memory for storing channel mapping information indicating correlation between a plurality of multicast communication channels and said plurality of buses, a packet analyzer for making a comparison between channel mapping information contained in a received message and said channel mapping information stored in said memory and initiating a channel acquisition routine for acquiring a multicast communication channel on a bus where no management bus is present if result of said comparison indicates that the destination address of the message matches a stored address and said received message is not received from a receive node, and a packet switching unit for forwarding the received message to said destination bus if a multicast communication channel is acquired in the destination bus of said received message or a new multicast communication channel can be acquired in said destination bus, and establishes a connection between channels indicated in said channel mapping information if the result of said comparison by said packet analyzer indicates that the destination address of the received message matches a stored address and a port number at which the message is received is different from a stored port number.

[0023]

According to claim 13, in the packet communication apparatus as claimed in claim 12, the present invention is further characterized by a packet transmitter for transmitting an enquiry message for determining whether a

management node is present on said destination bus when said packet switching unit initiates said channel acquisition routine.

According to claim 14, in the packet communication apparatus as claimed in claim 13, the present invention is further characterized by a timer for timing a predetermined amount of time for accepting said enquiry message and in that said amount of time for each bridge is different from each other.

[0024]

According to claim 15, in the packet communication apparatus for a communications network comprising a plurality of buses each including at least one node and being connected to each other via a plurality of bridges, said buses and said bridges performing operation under a standardized serial bus communication protocol, the present invention is characterized by a packet analyzer for initiating a channel acquisition routine for acquiring a multicast communication channel on a bus if a bus identifier contained in the received message indicates a bus which is other than the bus to which the source node of the message belongs, and a packet transmitter for transmitting an enquiry message for determining whether a multicast communication channel is acquired when said packet analyzer initiates said channel acquisition routine.

According to claim 16, in the packet communication apparatus as claimed in any one of claims 11 to 15, the present invention is characterized in that said standardized serial bus communication protocol is the protocol specified by the IEEE 1394 standard.

[0025]

The following is a description of the operation of the present invention.

According to the communication method of the present invention as defined by claim 1, a plurality of buses are interconnected by a plurality of bridges. When the nodes attached to each of the buses initiate multicast group communication using respectively different channels, the bridges establish connections between channels of said different buses. This enables communication to proceed over different channels.

According to the communication method of the present invention as defined by claim 2, a plurality of buses are interconnected by a plurality of bridges and multicast packets are transferred over the bridges. The source node on each of the buses acquires a channel for the multicast group and broadcasts a message indicating the relationship between the multicast group and the channel at periodic intervals. The bridges examine the broadcast messages. If

the bridge receives multicast group messages from different buses that are connected to the bridge that describes the same multicast group identifier, the bridge establishes connection between the channels of these buses to enable multicast packets to be transferred over the channels.

[0026]

According to the communication method of the present invention defined by claim 3, a plurality of buses are connected to the opposite ends of a bridge, and the source node on each of the buses acquires a channel for a multicast group and broadcasts a mapping message at periodic intervals indicating the relationship between the multicast group and its channel identifier. Each bridge examines the mapping messages. If the bridge receives multicast group messages from the buses on its opposite sides that describes the same multicast group identifier, the bridge transmits an enquiry message asking if a channel is acquired for a multicast address within the bus that is directly connected to the bridge. If no response is returned for this enquiry message, the bridge initiates a channel acquisition routine of its own accord and broadcasts a mapping message at periodic intervals indicating the relationship between the multicast group and channel identifiers and establishes connections between the channels to enable multicast packets to be transferred over the channels.

[0027]

Note that in the present invention as defined by claims 2 and 3, when stopping the transmission of a packet destined for a multicast group, the source node can do this by returning the assigned multicast channel to the isochronous resource manager (IRM) and at the same time stops transmitting the mapping message. Further, the bridges that interconnected the multicast channels of different buses cut off channels and stops sending packets across the buses if no mapping messages are received from buses connected to its opposite sides.

[0028]

According to the communication method of the present invention defined by claim 4, if there is a bus having receive-only nodes on a communication path (no source node exists), and if there is a bus on which there is a source node that performs multicast transmission, the source node acquires a channel for the multicast group and broadcasts a message mapping the relationship between the multicast group and the acquired channel at periodic intervals. A receive node, on receiving the broadcast message, sends

an enquiry message asking if a channel for this multicast group is assigned. If no response is returned, the receive node acquires the channel of its own accord and broadcasts a message mapping the relationship between the multicast group and the acquired channel at periodic intervals. The bridge connected between these source node and receive node establishes connection between the channels of the buses on which these nodes attached to perform transmission of packets.

[0029]

Note that in the present invention as defined by claim 4, when stopping the transmission of a packet destined for a multicast group, the source node can do this by freeing the channel assigned to the multicast group and stopping the transmission of the mapping message describing the relationship between the multicast group and the freed channel. In this case, the node that is receiving a multicast packets transmits a message indicating that the channel management right is returned, looking for a node that desires ownership of the channel. If there is no node that responds to this message, the receive node simply cut off the channels of these buses to cease the packet transfer between the buses.

[0030]

[Modes of Implementation of the Invention]

The following is a description of the modes of implementation of the present invention with reference to the accompanying drawings.

Note that in each drawing elements corresponding in significance are marked with the same numerals throughout.

<Embodiment 1>

The packet communication method and apparatus associated with the embodiment 1 makes it possible to perform multicast packet transfer between a plurality of buses interconnected by bridges.

[0031]

Fig. 1 shows a communication network of embodiment 1 of the present invention. This network is provided with a plurality of buses 509 through 511 compliant with the IEEE 1394 serial bus standard and in each of these buses a plurality of IEEE-1394 compliant nodes 501 through 506 and these buses are interconnected by IEEE-1394 compliant bridges 507 and 508. The number of nodes attached to each bus is not limited. Only one node may be attached to a bus. Each bridge is provided with a port A and a port B and the port of each node and bridge has a data link layer function compliant with the IEEE 1394

standard.

[0032]

Nodes 501 and 502 are serially interconnected via bus 509, which is in turn connected to the port A of bridge 507. Nodes 503 and 504 are serially interconnected via bus 510, which is in turn connected to the port B of bridge 507 and the port A of bridge 508. Further, the nodes 505 and 506 are serially interconnected via bus 511, which is in turn connected to the port B of bridge 508. At least one of nodes on each bus is capable of operating as an isochronous resource manager (IRM) standardized by the IEEE 1394. In the illustrated embodiment, the nodes 502, 504 and 506 are assumed to operate as an IRM node.

[0033]

Each node of the network is provided with a communication protocol such as TCP/IP (Transmission Control Protocol)/IP (Internet Protocol) standardized by such a body as IETF (Internet Engineering Task Force), and IP over IEEE 1394 (RFC 2734) also standardized by the IETF. Using the IEEE 1394 functions, the nodes of the network are able to transport IP packets within their own bus. In addition, each bridge is provided with a function that enables it to transfer unicast packets and broadcast packet between the buses that are connected to the bridge. IP unicast packets and IP broadcast packets are transmitted between the buses. Note that the present invention is not limited to the TCP/IP and IP over IEEE 1394 standard. Any protocol can equally be used as well.

[0034]

In the embodiment 1, the nodes that participate in a multicast group use multicast group IP address A1 as a destination address and UDP (User Datagram Protocol). The parameters that specify a multicast group are not to be limited to the combination of such destination address and protocol, but to any combination.

[0035]

Fig. 2 is an illustration of the format of data to be set in a control message used between the nodes and the bridges. This data includes a node identification number 601, a message type 602, a channel number 603, and a destination address 604. The node identification number 601 of a node is made up of a bus identifier identifying the bus to which the node is attached and the identifier of the node that is unique to the bus. In the case of the node 501, for

example, the node identification number comprises the identifier of the bus 509 and the identifier of the node 501. The value of the message type 602 of a source node is of four types: "enquiry", "report from source node", "report from receive node" and "transfer of channel use". The message type "enquiry" is used by a node wishing to transmit a packet to a multicast group to ascertain whether a channel is acquired for the intended multicast group. The message type "report from source node" is used by transmit-only nodes or receive/transmit nodes to provide management of channels to be exclusively used for multicast groups and includes information indicating the addresses of multicast groups and channel numbers and mapping data representing the relationships between the multicast groups and the channel numbers. The message type "report from receive node" is used by receive-only nodes as well as by the bridges to provide management of channels to be exclusively used for multicast groups and includes information indicating the addresses of multicast groups and channel numbers and mapping data representing the relationships between the multicast groups and the channel numbers. The message type "transfer of channel use" is used by a node which has been the owner of a multicast channel when it discontinue the ownership to ascertain if there is other node to assert the ownership of the channel.

[0036]

The value of the channel number 603 is set in the range between integers "0" through "63", with the exception of integer "31" which is exclusively used for the broadcast channel. The value of the destination address 604 is set in the range in which multicast group addresses are selected from among IP addresses. More specifically, it ranges from "224.0.0.1" through "239.255.255.255". Note that the format of the message is not be limited to that described above.

[0037]

The following is a description of the procedure of the packet communication method of the embodiment 1 with reference to Fig. 3 by assuming that multicast packets are exchanged between the nodes 501 and 503 over the bridge 507.

Since the IEEE 1394 allows acquisition of a channel for a multicast packet transmission in advance, the node 501 first broadcasts an enquiry message to the associated buses asking if a channel has already been acquired for a multicast session (procedure S701). The value of each information

contained in this message indicates that the node identifier 601 includes "the identifiers of bus 509 and node 501", the message type 602 is set to "enquiry", and the destination address 604 is set equal to "A1". This multicast destination address 604 is specified by an application program that operates on the TCP/IP and which multicast address is to be used is determined by the application program installed on each node. If no reply is received in response to the message transmitted in the above mentioned procedure S701, the node 501 initiates a channel acquisition routine to the IRM node 502 to obtain the channel "C1" (procedure S702).

[0038]

After the channel "C1" is obtained, the node 501 sends a broadcast message at periodic intervals indicating a mapping relationship between the multicast group and the channel (henceforth called channel mapping information) (procedure S703). The value of the information contained in the message of this procedure S703 is that the node identifier 601 indicates the identifiers of bus 509 and node 501 and the message type 602 indicates "report from source node" and the channel number 603 is "C1" and the destination address 604 is "A1".

[0039]

On receiving the message transmitted on the above mentioned procedure S703, each of the bridges 507 and 508 examines the report from the source node, extracts and stores the information contained therein including the node identification number "bus 509 identifier and node 501 identifier", the message type "report from source node", the channel number "C1", the destination address "A1" and the port "A" of bridge 507 at which this message was received and the port "A" of bridge 508 (procedure S704). Node 501 uses the acquired channel "C1" to initiate the transmission of asynchronous stream packets (procedure S705).

[0040]

On the other hand, when the node 503 on the bus 510 initiates transmission of multicast packets in the same way as the node 501 sends a broadcast enquiry message (procedure S706) asking if a channel for the multicast group has been acquired. The value of the information contained in this enquiry message is that the node identification number 601 includes "the bus 510 identifier and the node 503 identifier", the message type 602 is "enquiry", and the destination address 604 is set equal to "A1". If no reply

message is returned in response to this enquiry broadcast message, the node 503 initiates a channel acquisition routine on the IRM node 504 to acquire a channel "C2" (procedure S707). If no response is returned despite the fact that the node 501 has already acquired a multicast channel, the reason for this may possibly be that, since the channel mapping information is only valid within a bus in which the IRM node is present, there is no node in the bus that responds to the enquiry message from the external bus. Following the acquisition of the channel "C2", the node 503 broadcasts channel mapping information (procedure S708). The value of the information contained in this message is that the node identifier 601 indicates the identifiers of bus 510 and node 503 and the message type 602 indicates "report from source node" and the channel number 603 is "C2" and the destination address 604 is "A1".

[0041]

On receiving the message transmitted in the above mentioned procedure S708, the bridge 507 examines the report from the source node and extracts the information from the message and stores the node identification number "bus 510 identifier and node 503 identifier", the channel number "C2", the destination address "A1" and the port "B" of bridge 507 (procedure S709). In the same way, the bridge 508 extracts the information from the message and stores the node identification number "bus 510 identifier and node 503 identifier", the channel number "C2", the destination address "A1" and the port "A" of bridge 508 (procedure S709).

[0042]

Next, the bridge 507 makes comparisons between the information received from the bus 509 that is directly connected to the port A of this bridge and stored in procedure S704 and the information received from the bus 510 that is directly connected to the port B of this bridge and stored in procedure S709. If they differ from one another, i.e., the bridge has received information of the same multicast group from different buses, the bridge 507 establishes a connection between the channels of these buses. More specifically, if the two information received on the ports A and B, and match in the destination address 604 and mismatch in the received port numbers, and the node number 601 indicates that the message is received from the directly connected buses, and both messages do not contain the message type "report from receive node", the bridge 507 correlates the channels specified by the channel number 603 contained in these information and establishes a connection between the

specified channels (procedure S710).

[0043]

This inter-channel connection is achieved by converting the channel number of the asynchronous stream packet. If the channel "C1" of bus 509 is connected to the channel "C2" of bus 510, for example, the bridge 507 translates the channel number C1 to the channel number C2 for packet transfer from the bus 509 to bus 510. Conversely, the bridge 507 translates the channel number C2 to the channel number C1 for packet transfer from the bus 510 to bus 509. In this way, the channels C1 and C2 of the buses 509 and 510 are interconnected via the bridge 507, allowing packets on different buses 509 and 510 to be transported across the bridge 507. In the same manner, the bridge 508 establishes inter-channel connections between the channels of the different buses directly connected thereto.

[0044]

If the message types of both messages are "report from receive node", no channel interconnection is performed. The reason for this is that there is no source node on the buses, and hence no multicast packets need to be transmitted.

In addition, the bridge 508, on receiving a message transmitted in procedure S708, operates in the same manner as that of the bridge 507 by making comparisons between the information stored in procedure S704 and the information stored in procedure S709. Since the port numbers of the compared messages coincide with each other (i.e., they are both port number A), no inter-channel connection is performed. In other words, the bridge 508 is connected in such a position where no nodes exist across the bridge 508 and hence no channels exist for the bridge 508 to interconnect.

[0045]

Following the establishment of a connection between the channel C1 of bus 509 and the channel C2 of bus 510 across the bridge 507, the packets of node 503 to destination address A1 are transmitted as asynchronous stream packets to the channel C2 of the bus 510. Bridge 507 then transfers the asynchronous stream packets on the channel C2 to the channel C1 on the bus 509 (procedure S711). Likewise, the packets from the node 501 destined to the address A1 are transmitted as asynchronous stream packets to the channel C1 on the bus 509 and the bridge 507 transfers the packets on the channel C1 to the channel C2 on the bus 510 (procedure S712).

In this manner, multicast packet transmission is established between the buses 509 and 510 over the bridge 507.

[0046]

The following is a description of procedures in which the node 501 ceases the multicast transmission.

Fig. 4 is an illustration of procedures in which the node 501 terminates a multicast packet session which has been established by the node 507 between the buses 509 and 510. Based on the procedures described in Fig. 3, the node 501 interrupts the communication between the nodes 501 and 503 (procedure S801). The termination of the multicast communication is followed by the node 501 sending a broadcast message that indicates that the node 501 is willing to abandon the ownership of the channel (procedure S802).

[0047]

The value of each of the information contained in the message transmitted in procedure S802 includes node identification number 601 that contains "bus 509 identifier and node 501 identifier", message type 602 indicating "transfer of channel use", channel number 603 being C1 and the destination address 604 being A1. The bridge 507, on receiving this message, examines its contents. If it recognizes that the bus identification number is that of the bus to which the bridge 507 is directly connected, the bridge 50 extracts the bus 509 identifier and the node 501 identifier, the channel number C1 and the address A1 from the received message and stores the extracted information (procedure S803).

[0048]

Bridge 507 then examines messages received within a predetermined time interval Ta from the instant it received the transfer-of-channel-ownership message, and recognizes that there is no node that belongs to the multicast group whose address is A1 and disconnects the communication between the buses 509 and 510 if it does not receive messages within that interval that contain address 604 = A1, and the message type = "report from source node" or "report from receive node". Following the termination of the inter-channel connection by the bridge 507, the node 501 restores the ownership of the multicast channel C1 to the IRM node 502 (procedure S805). One example of this procedure is described below.

Within a predetermined time interval following the transmission of the transfer-of-channel-ownership message, the node 501 releases the channel open

to possible assertions from other nodes within a predetermined time interval Td. By setting the time interval Td > Ta, the node 501 can safely restore the ownership of a channel after the bridge 507 has disconnected the channel.

[0049]

The following is a description of the reason why the node 501 restores the ownership of a channel after the bridge 507 disconnected the channel in the above described procedure S804. Assume that the node 501 returns the ownership of the channel C1 before the bridge 507 disconnects this channel, possibilities exists, during the interval between the instant the node 501 returns the ownership of channel C1 and the instant the channel C1 is disconnected, that IP-over-IEEE-1394 compliant nodes that exist on the bus 509 may assert the ownership of a multicast address other than the address A1 or any node on the bus 509 may assert the ownership of the same channel C1 for purposes other than IP over IEEE 1394 and the bridge 507 transfers packets destined to the address A1 on bus 510 to the bus 509. In such instances, packets destined for the multicast group in which the node 501 is participating would be routed in error to an unintended node or routed to an application other than the IP over IEEE 1394 application. In order to prevent this erroneous routing of packets destined to address A1 to the channel C1 before the ownership of the latter is abandoned, the ownership restoration of a channel is performed following the disconnection of the channel. Following the disconnection of inter-channel communication by the bridge 507, the node 501 returns the ownership of channel S1, the packets from the node 503 to the address A1 are not transferred by the bridge 507. They are limited to within the confines of the bus 510 (procedure S806).

[0050]

The following is a detailed description of the structure and operation of the bridges of the embodiment 1 of the present invention.

Fig. 5 is an illustration of the structure of the bridge 1301 that corresponds to the bridges 507 and 508 of the embodiment 1. This bridge 1301 is comprised of a memory 1302, a timer 1303, a packet assembler 1304, a packet analyzer 1305 and a packet switching unit 1306. Packets are transmitted via the ports A and B between the bus α (corresponding to the bus 509 or 510) and a bus β (corresponding to the bus 510 or 511). The operation of the function of each constituent element of this bridge 1301 is apparent from the description given below. Note that bridge 1301 will be referred to as bridge 507 or 508 in

the following description where appropriate.

[0051]

The following is a description of the operation of the bridges 507 and 508 of the embodiment 1.

Initially, the description is concerned with the operation of the bridge 507 when it receives a message containing the channel mapping information for multicast transmission (step S703).

In the bridge 1301 (bridge 507), the channel mapping information for a multicast transmission that is received at the port A to which the bus α (bus 509) is connected is sent to the packet switching unit 1306 and to the packet analyzer 1305 as well. The packet switching unit 1306, on receiving this channel mapping information, sends an enquiry message to the IRM node to verify whether a channel has been acquired for this multicast group within the bus β (bus 510) or a channel can be acquired. If a channel has already been acquired or can be acquired, this message is sent to the port B and to the bus β (bus 510).

[0052]

The reason for restricting the transfer of packets by performing such a verification process is to prevent wasteful acquisition of channel resource and to enhance the channel utilization efficiency on each bus. More specifically, if there is a bus that fails to acquire a channel that interconnects two nodes that are participating in a multicast group activity, no interconnection can be established between these two nodes even if the other node is successful in the attempt to acquire a channel. In such instances, no attempt is made on a bus to acquire a channel even if it is available on that bus. This allows other nodes to use that channel and efficient utilization can be achieved.

[0053]

Packet analyzer 1305, on detecting the channel mapping information for a multicast transmission contained in the received message, extracts the bus 509 identifier, node 501 identifier, message type "report from source node", channel number C1, destination address A1 and port number A from the received message and checks the contents of the memory 1302. Since no data is stored in the memory 1032 at this moment, the extracted data is stored into the memory 1302 (procedure S704).

[0054]

Next, the following is a description of the operation of the bridge 507 when it receives the channel mapping information for a multicast transmission

in the above mentioned procedure S708.

In the bridge 1301 (bridge 507), the multicast channel mapping information received on port B to which the bus β (bus 510) is connected, is sent to the packet switching unit 1306 as well as to the packet analyzer 1305. The packet switching unit 1306, on receiving the channel mapping information, inquires the IRM about to verify if a channel has been acquired for the multicast group within the destination bus α (bus 509) or a new channel can be acquired. If this verification indicates that a channel has already been acquired or a new channel can be acquired, this message is transferred to the port A and transmitted to the bus α (bus 509). The reason to perform this verification process is the same as discussed above.

[0055]

Packet analyzer 1305, on receiving the channel mapping information, extracts the bus 510 identifier, node 503 identifier, message type "report from source node", channel number C2, destination address A1 and port number B from the received message and checks the contents of the memory 1302. Since the channel mapping information of procedure 704 is already stored in the memory 1032 at this moment, the extracted channel mapping information of the message received in the above mentioned procedure S708 is compared with the channel mapping information stored in the memory 1302 (procedure S704).

[0056]

If it is determined that there are a match between the destination addresses 604 and a mismatch between the ports of the received messages, and the node 601 identifier is on the directly connected bus and both message types 602 are other than "report from receive node", the packet switching unit 1306 establishes a connection between the channels C1 and C2 identified by the channel numbers specified in the respective channel mapping information (procedure S710) and stores information indicating that channels C1 and C2 are connected into the memory 1302.

[0057]

The following is a description of the operation of the packet switching unit 1306 of the bridge 507 to perform packet transfer to the multicast group in procedures S711 and S712 after the connection between the channels corresponding to the multicast address A1 is established according to the above mentioned procedure S710.

Bridge 1301 (bridge 507) receives this multicast packet on one of its

ports A and B and sends it to the packet analyzer 1305 and the packet switching unit 1306. Packet analyzer 1305 does not process the multicast packet by simply discarding it. Since the packet switching unit 1306 is able to know that that the channels through which the packets are received are interconnected by the above mentioned procedure S710 by referring to the memory 1302, it converts the channels and transmits a packet to the port that is opposite to the port on which the packet is received (procedures S711, S712).

[0058]

The following is a description of the operation of the packet switching unit 1306 of the bridge 507 to perform transfer of channel ownership in procedure S802 after the connection between the channels corresponding to the multicast address A1 is established according to the above mentioned procedure S710.

In procedure S802, when the bridge 507 receives a transfer-of-ownership message from the bus α (bus 509) through port A, it sends the message to the packet analyzer 1305 and the packet switching unit 1306. Since this message is broadcast, the packet switching unit 1306 transfers this message to the opposite port B for transmission to the bus β (bus 510).

[0059]

Packet analyzer 1305 recognizes from the node identifier of this message that the message is a transfer-of-channel-ownership message that arrived from the bus directly connected to the bridge 507, and stores the bus 509 identifier, the node 501 identifier, channel number C1, and destination address A1 into the memory 1302 (procedure S803). Simultaneously with procedure S803, the timer 1303 is activated to start a timing operation to measure the length of time (Ta).

[0060]

The following is a description of the bridge 507 when it disconnects the channels in procedure S804, following the receipt of a transfer-of-channel-ownership message in the above mentioned procedure S802.

In the bridge 507, the packet switching unit 1306 is instructed to disconnect the channels if it fails to receive a message within the time-out period of the timer 1303, indicating that the node identification number 601 includes the bus 509 identifier, and the destination address 604 is A1 and the message type 602 is "report from source node" or "report from receive node" (procedure S804).

[0061]

As described above, according to the communication network of the embodiment 1 which includes a plurality of nodes having the IEEE 1394 functions attached to a plurality of buses which are interconnected by bridges, multicast transmission is made possible across the bridges between the buses by interconnecting channels acquired for the multicast transmission.

In addition, if there are two buses on which multicast channels are acquired and multicast packet transmission is performed using the acquired channels, the bridges interconnect such buses by correlating the multicast channels to the multicast groups to enable the transmission of the multicast packets across the bridges.

[0062]

In addition to that described above, since each of the bridges is supposed to interconnect those multiple buses that are involved for transmission of packets for the same multicast session, each of the nodes interconnected on these buses via the bridges is able to transmit multicast packets transparently without considering the presence of bridges.

In addition, the buses on which no multicasting nodes exist or the buses through which no multicast packets are routed, no channels are acquired and no packet transmission is performed. As a result, it is possible to efficiently operate a network that is compliant with the IEEE 1394 standard.

In addition, in the first embodiment of the present invention, channel acquisition is only performed on buses 509 and 510 on which nodes that participate in a multicast group activity exist and packet transfer is only performed between the buses 509 and 510.

[0062]

<Embodiment 2>

The following is a description of an embodiment 2 of the present invention.

The packet communication method of the embodiment 2 is to enable transmission of multicast packets over a communication path in which no channel is acquired in one or more buses. The communications network of the embodiment 2 is similar to the embodiment 1 as shown in Fig. 5 and the format of the messages used in the embodiment 2 is similar to the embodiment 1 as shown in Fig. 6. The following description of the embodiment 2 is limited to those that differ from the previous embodiment.

[0064]

In Fig. 6, it is assumed that the nodes 501 and 505 of Fig. 1 participate in the same multicast group to transmit multicast packets between the bus 509 connected to the bridge 507 and the bus 511 connected to the bridge 508. Fig. 6, in which parts corresponding to those in Fig. 3 of the embodiment 1 are marked with the same numerals, shows a sequence of procedures for initiating a communication.

[0065]

In a manner similar to the embodiment 1, when the node 501 transmits a packet to the multicast group it belongs, it sends an enquiry message asking whether a channel for the multicast group has been acquired (procedure S701). The value of each information contained in this message indicates that the node identifier 601 includes "the identifiers of bus 509 and node 501", the message type 602 is "enquiry", and the destination address 604 is set equal to "A1". If no reply message is received in response to this message, the node 501 initiates a channel acquisition routine to the IRM node 502 to obtain the channel "C1" (procedure S702).

[0066]

Following the execution of procedure S702, the node 501 broadcasts channel mapping information at periodic intervals indicating a mapping relationship between the multicast group and the acquired channel (procedure S703). The value of the information contained in the message of this procedure S703 is that the node identifier 601 indicates the bus 509 identifier and the node 501 identifier and the message type 602 indicates "report from source node" and the channel number 603 is set equal to "C1" and the destination address 604 is set equal to "A1".

[0067]

On receiving the message transmitted on the above mentioned procedure S703, each of the bridges 507 and 508 examines the report from the source node, extracts and stores the information contained therein including the node identification number "bus 509 identifier and node 501 identifier", the message type "report from source node", the channel number "C1", the destination address "A1" and the port "A" of bridge 507 at which this message was received and the port "A" of bridge 508 (procedure S704). Node 501 uses the acquired channel "C1" to initiate the transmission of asynchronous stream packets (procedure S705).

[0068]

Next, when the node 505 on the bus 511 initiates transmission of multicast packets in the same way as the node 501 sends a multicast packet, the node 505 transmits an enquiry message asking if a channel for the multicast group has been acquired (procedure S901). The value of the information contained in this enquiry message is that the node identification number 601 includes "the bus 511 identifier and the node 505 identifier", the message type 602 is "enquiry", and the destination address 604 is set equal to "A1". If no reply message is returned in response to this enquiry message, the node 505 initiates a channel acquisition routine on the IRM node 506 to acquire a channel "C3" (procedure S902). Following the execution of procedure S902, the node 505 broadcasts channel mapping information (procedure S903). The value of the information contained in this message is that the node identifier 601 includes the bus 511 identifier and the node 505 identifier and the message type 602 indicates "report from source node" and the channel number 603 is set equal to "C3" and the destination address 604 is set equal to "A1".

[0069]

On receiving the message transmitted in the above mentioned procedure S903, each of the bridges 507 and 508 extracts the node identification number including "the bus 510 identifier and the node 503 identifier", the channel number "C3", the destination address "A1" and the port "B" of bridge 507 or the port B of bridge 508 at which the message is received, and compares the extracted data with the data previously received at the opposite-side port A of the bridges in the above mentioned procedure S704.

[0070]

If the comparison indicates that the destination addresses 604 coincide with each other, and the port numbers at which messages are received does not coincide with each other, and the message types are other than "report from receive node" and the source node of one of the messages is located on a bus on the far side of a bus in which no channel is acquired (i.e., bus 510), each of the bridges 507 and 508 initiates a channel acquisition routine for the multicast group on the sourceless bus 510 (procedure S904). In other words, each bridge initiates a channel acquisition routine for a multicast group on the bus to which it is directly connected and in which no node is present for participating in the multicast group, on conditions that the bridge has received a message describing the same multicast group from a bus located on the far side of the

directly connected bus.

[0071]

Simultaneously with the starting of the above mentioned procedure S904, the bridge 507 transmits an enquiry message asking if a channel for the multicast group has been acquired (procedure S905). The value of the information contained in this enquiry message is that the node identification number 601 includes "the bus 510 identifier and the bridge 507 identifier", the message type 602 is "enquiry", and the destination address 604 is set equal to "A1". A similar procedure is executed by the bridge 508 on the bus 510 for broadcasting an enquiry message (procedure S906). The value of the information contained in this enquiry message is that the node identification number 601 includes "the bus 510 identifier and the bridge 508 identifier", the message type 602 is "enquiry", and the destination address 604 is set equal to "A1".

[0072]

After executing the above mentioned channel acquisition procedure S904, the bridge 507 monitors the bus for detecting an enquiry message transmitted in the above mentioned procedure S906. When this enquiry message is received, the bridge 507 checks to see if the node identification number it contains coincides and the destination address 604 coincides. If this is the case, the bridge 507 compares the received node identifier with its own node identifier. If its own node identifier is greater than the received node identifier, the bridge 507 acquires a channel for the multicast group from the IRM node in the usual manner. If its own node identifier is smaller than the received node identifier, the bridge 507 extends its waiting time to start a channel acquisition routine to prevent a collision which may possibly occur between two attempts to acquire a channel simultaneously. In the embodiment 2 it is assumed that the node identifier of the bridge 507 has a greater value.

[0073]

In like manner, the bridge 508 monitors the bus for detecting an enquiry message transmitted in the above mentioned procedure S905 after the bridge 508 executed the above mentioned channel acquisition procedure S904. When this enquiry message is received, the bridge 508 checks to see if the node identification number it contains coincides and the destination address 604 coincides. If this is the case, the bridge 508 compares the received node identifier with its own node identifier. If its own node identifier is greater than

the received node identifier, the bridge 508 acquires a channel for the multicast group from the IRM node in the usual manner. If its own node identifier is smaller than the received node identifier, the bridge 508 extends its waiting time to start a channel acquisition routine. Since the node identifier of the bridge 507 has a greater value than the bridge 508, the bridge 508 extends its waiting time to start the channel acquisition process, allowing the bridge 507 to acquire the channel C2 from the IRM node earlier than the bridge 508 (procedure S907).

Note that the channel acquisition process may be initiated first by a bridge having a lower number of node identifier. A random number may also be used to determine the priority.

[0074]

Following the above mentioned procedure S907, the bridge 507 sends a broadcast message for reporting channel mapping information at periodic intervals (procedure S908). The node identification number of this broadcast message includes the bus 510 identifier and the bridge 507 identifier, the message type 602 is "report from receive node", the channel number 603 is set equal to "C2" and the destination address 604 is set equal to "A1". If the bridge 507 receives a message describing the same multicast group from a bus different from the bus on which the enquiry message was transmitted in procedure S908, the bridge 508 establishes a connection between the channels of these buses. Note that since the enquiry message of procedure S908 is a broadcast packet, it is sent to the bus 509 where no channel is acquired. However, this does not constitute a condition for the bridge 507 to perform channel connection. More specifically, the bridge 507 establishes a connection between the channel C1 of the bus 509 which was stored in procedure S704 and the channel C2 of bus 510 which was contained in the message transmitted in procedure S908 (procedure S909). In like manner, the bridge 508 establishes a connection between the channel C3 of bus 511 which was stored during procedure S704 and the channel C2 which was contained in the message transmitted during procedure S908 (procedure S909).

[0075]

Transmit packets that contain the destination address A1 are transmitted from the node 501 as asynchronous stream packets to the channel C1. Bridge 507 repeats the asynchronous stream packets transmitted on the channel C1 of the bus 509 on to the channel C2 of the bus 510. Bridge 508

repeats the asynchronous stream packets transmitted on the channel C2 of the bus 510 on to the channel C3 of the bus 511 (procedure S910).

In like manner, transmit packets that contain the destination address A1 are transmitted from the node 505 as asynchronous stream packets to the channel C3. Bridge 508 repeats the asynchronous stream packets transmitted on the channel C3 of the bus 511 on to the channel C2 of the bus 510. Bridge 507 repeats the asynchronous stream packets transmitted on the channel C2 of the bus 510 on to the channel C1 of the bus 509 (procedure S911).

[0076]

The following is a description of the packet communication method with reference to Fig. 7 when a multicast packet transfer is terminated.

In the embodiment 2, Fig. 7 shows a sequence of procedures when the mode of transmission changes from a multicast transmission over the buses 509, 510 and 511 to the state of inactivity. In Fig. 7, parts corresponding in significance to those of Fig. 4 of the embodiment 1 are marked with the same reference numerals.

Node 501 stops sending packets (procedure S801) during a communication mode in which it performs a session with the node 505 according to the procedures shown in Fig. 6. Accompanying the procedure S801, the node 501 broadcasts a transfer-of-channel-ownership message to release the acquired channel (procedure S802). This broadcast message includes the node identification number 601 that contains the bus 509 identifier and the node 501 identifier, the message type 602 which is "transfer of ownership", the channel number 603 which is set equal to C1 and the destination address 604 which is set equal to A1.

[0077]

On receiving the message transmitted according to the above mentioned procedure S802, the bridge 507 examines this transfer-of-channel-ownership message. If the bus identifier of this message coincides with the bus identifier of the bus to which the bridge 507 is directly connected, the bridge 507 stores the bus 509 identifier, the node 501 identifier, channel number C1, and the destination address A1 into memory (procedure S803). Within a predetermined time interval Ta, the bridge 507 monitors the buses for a message containing the bus 509 identifier, the address A1 and message type "report from source node" or "report from receive node". If no such message is received within that time interval, the bridge 507 clears down the connection

between the buses 509 and 510 (procedure S804). When this occurs, the bridge 507 erases the information from the memory 1302 that indicates that the channels C1 and C2 are connected.

[0078]

Simultaneously with the above mentioned clear-down operation, the bridge 507 restores the ownership of multicast group channel C2 of the bus 510 to the isochronous resource manager and begins a channel release process on this channel C2 (procedure S1001). Simultaneously with this, the bridge 507 broadcasts a transfer-of-channel-ownership message (procedure S1002). In this message, the node identification number 601 includes "bus 510 identifier and the bridge 507 identifier", the message type 602 is "transfer-of-channel-ownership", the channel number 603 is set equal to C2 and the destination address 604 is set equal to A1.

[0079]

On receiving this transfer-of-channel-ownership message, the bridge 508 examines this message. If the bus identifier of this message is the same as that of the bus to which the bridge 508 is directly connected, the bridge 508 stores the bus 510 identifier and the bridge 507 identifier, the channel number C2, and the destination address A1 into memory (procedure S1003). Then, the bridge 508 monitors the buses for a predetermine time interval Ta that runs from the instant it received the transfer-of-channel-ownership message. If the bridge 508 does not receive a message containing the bus 510 identifier, the destination address A1, and the message type "report from source node" or "report from receive node", the bridge 508 clears the channel connection between the buses 510 and 511 (procedure S1004).

[0080]

When the channel connection is cleared by the bridge 507 according to procedure S804 following the broadcasting of message under procedure S802, the node 501 restores the ownership of the multicast channel C1 to the IRM node 502 (procedure S805).

In like manner, when the channel connection is cleared by the bridge 508 according to procedure S1004 following the broadcasting of message under procedure S1002, the node 507 restores the ownership of the multicast channel C2 to the IRM node 502 (procedure S1005).

Following the clear-down of the channel by the bridge 508 according to the above mentioned procedure 1004, the transmit packet to the multicast group

from the node 506 is not transferred by the bridge 508 and transferred within the bus 511.

[0081]

The following is a detailed description of the structure and operation of the bridge of the embodiment 2 with reference to Fig. 5.

The bridge of the embodiment 2 is constructed of a memory 1302, a timer 1303, a packet assembler 1304, a packet analyzer 1305 and a packet switching unit 1306 in a manner similar to the bridge 1301. Packets are received and transmitted through ports A and B and forwarded onto the bus α (bus 509 or 510) or the bus β (bus 510 or 511). The operation of the bridge 1301 according to the embodiment 2 becomes apparent from the following description.

[0082]

First, in the procedure S703 of Fig. 6, the description begins with the operation of the bridge 507 when the latter receives channel mapping information.

In procedure S703, the bridge 1301 (bridge 507) transmits the channel mapping information that is received through the port A from the bus α (bus 509) to the packet switching unit 1306 and the packet analyzer 1305. Packet switching unit 1306 verifies if a channel is acquired within the destination bus β (bus 510) or a new channel can be acquired for a multicast group by sending an enquiry message to the IRM node. If this is the case, the channel mapping information is transmitted through the port B to the bus β (bus 510). As described above, the reason to perform verification is to enhance the channel utilization efficiency.

[0083]

On receiving the channel mapping information from the port A to which the bus α (bus 509) is connected as described in relation to the above mentioned procedure S703, the packet analyzer 1305 extracts the bus 509 identifier and the node 501 identifier, the message type "report from source node", the channel number "C1", the destination address "A1" and the port number A on which the message is received, and makes a search through the memory 1302 for any information stored therein. Since no information is stored in this memory, the packet analyzer 1305 stores the extracted information into the memory 1302 (procedure S704).

[0084]

Next, the following is a description of a sequence of operations in the

above described procedure S903 when the bridge 507 receives a channel mapping information regarding multicast transmission.

In the above mentioned procedure S903, the channel mapping information received through the port B to which the bus β (bus 510) is connected is forwarded to the packet switching unit 1306 and the packet analyzer 1305. On receiving this channel mapping information, the packet switching unit 1306 to verify this message by sending an enquiry message to the IRM node as to whether a channel has been acquired for this multicast group within the destination bus α or whether a new channel can be acquired for this multicast group. If this message is verified, a message containing the channel mapping information is forwarded through the port A to the bus α (bus 509).

[0085]

On receiving the channel mapping information from the port B in the above described procedure S903, the packet analyzer 1305 extracts the bus 511 identifier and the node 503 identifier, the message type "report from source node", the channel number "C3", the destination address "A1" and the port number B on which the message is received, and makes a search through the memory 1302 for any information stored therein. Since the receipt of channel mapping information of procedure S703 is stored in procedure S704, the two information are compared with each other. Specifically, the packet analyzer 1305 compares the multicasting channel mapping information contained in the newly received message with the channel mapping information already stored in the memory 1302.

[0086]

If the result of the comparison by the packet analyzer 1305 indicates that the destination address fields 604 of both information match and the port numbers on which the messages are received differ from each other, the message types 602 of both information are not "report from receive node", the packet analyzer 1305 initiates a routine for acquiring a multicast channel on the bus β (bus 510) in which no management node exists (procedure S904). Note however that the conditions under which such a routine is initiated are not limited to those described above. Appropriate settings can also be made. At the start of this procedure S904, the packet assembler S1304 sends an enquiry message as to whether a channel management node exists on the bus β (bus 510) (procedure S905). In addition to this, the timer 1303 starts a timing action to set up a time-out period for the reception of a reply message as a response to

the enquiry message of procedure S905.

[0087]

The following is a description of a sequence of operation when the bridge 507 sends an enquiry message in the above described procedure S905 and at the same time the bridge 508 receives a similar enquiry message in procedure S906.

The enquiry message received in procedure S906 on the port B to which the bus β (bus 510) is connected are forwarded to the packet switching unit 1306 and the packet analyzer 1305. Packet switching unit 1306 forwards this message to the bus a (bus 509) since this message is destined for a broadcast group.

[0088]

Packet analyzer 1305 recognizes, from the node identification number 601, the message type 602 and the destination address 604 contained in the message received in procedure S906, that this message is identical to the enquiry message received in procedure S905. If these messages are found to be identical to each other, the node identification number 601 of the message on procedure S905 is compared with the node identification number 601 of the message on procedure S906. If it is determined that the node identification number of bridge 507 is greater than the node identification number of bridge 508, nothing proceeds. If the node identification number of bridge 507 is smaller than that of bridge 508, a timing delay is introduce to the timer 1303 to extend the time-out period for receiving the reply message. In the embodiment 2 of the present invention, it is assumed that the node identification number of bridge 508 is smaller than that of the bridge 507, so that the timer of bridge 508 would be extended, while the timer of bridge 507 remains unchanged.

[0089]

By extending the time-out period of the timer 1303 of either bridge, one of the bridges 507 and 508 is given priority over the other when they compete for acquiring a channel on the bus 510, whereby duplicated acquisition of a single channel on the same bus 510 is avoided. Alternatively, a random number may be used to set up a time-out period so that one of the contending bridges is given priority.

[0090]

Next, the following is a description of a sequence of operations that occur in the above described procedure S905 when the timer is expired at the

end of the time-out period following the transmission of the enquiry message from the bridge 507.

When the timer 1303 is timed out in the bridge 507, the packet assembler 1304 formulates a packet for the acquisition of a channel (procedure S907) and performs a routine to acquire a channel from the IRM node 504 on the bus 510 (procedure S907). On receiving a notification message from the node 504 indicating that a channel has been successfully obtained, the bridge 507 terminates the channel acquisition process. Note that if the bridge 507 is an IRM node no packet is assembled for the acquisition of a channel. Instead, a channel acquisition routine is executed within the bridge 507.

[0091]

Next, the following is a description of a sequence of events that take place when the bridge 507 broadcasts multicast channel mapping information in procedure S908.

On receiving the channel acquisition notification message, the packet analyzer 1306 of the bridge 507 sends an instruction signal to the packet switching unit 1306 to establish an inter-channel connection (procedure S909). In response to this instruction signal fro the packet analyzer 1305, the packet switching unit 1306 establishes a connection between the channels specified in the channel mapping information. More specifically, the packet switching unit forwards this message to the destination bus if a channel has already been acquired on this bus or a new channel can be acquired. If the result of comparison by the packet analyzer 1305 indicates a match between destination addresses and a mismatch between the port numbers of the ports on which the packets are received, the packet switching unit establishes a connection between the channels specified in the channel mapping information. Furthermore, the packet analyzer 1305 notifies the packet assembler 1304 of the end of a channel acquisition process and formulates a report message for reporting the channel mapping information and stores this channel mapping information in the memory 1302.

[0092]

The message formulated in procedure S908 by the packet assembler 1304 is forwarded to each port and thence to each bus. Note however that since this message contains multicast channel mapping information, the bridge 507 inquires the IRM whether a channel is acquired for the multicast group or a new channel can be acquired on the destination bus α (bus 509). If this is the

case, this message is forwarded through the port A to the bus α (bus 509). Thereafter, packets destined for the multicast group "A1" are transported across the buses by the bridge 507. The channel information necessary for the above mentioned connection is stored in the memory 1302.

[0093]

The following is a description of a sequence of events that occur when data packets are transmitted to the multicast group in procedures S910 and 911 after the packet switching unit 1306 of bridge 507 has established a connection in procedure S909.

In the bridge 1301 (bridge 507), the packets destined for the multicast group are received at one of the ports A and B and forwarded to the packet analyzer 1305 and the packet switching unit 1306. Packet analyzer 1305 discards the received packets. Since the connection has already been established in procedure S909 between the two channels, the packet switching unity 1306 exchanges channels by forwarding the received packets to the other port which may be port B or A (procedures S910, S911).

[0094]

The following is a description of a sequence of events that occur when the bridge 507 receives a transfer-of-channel-ownership message in the above described procedure S802 after the packet switching unit 1306 of the bridge 507 established the connection in the above mentioned procedure 909 to the channel corresponding to the multicast address "A1".

Following the receipt of the transfer-of-channel-ownership message in procedure S802, if the bridge 507 receives no packet, within the time-out period Ta, that contains the bus 509 identifier, the destination address "A1", the message type of "report from source node" or "report from receive node", the timer 1303 runs out and a channel ownership restoration routine is initiated to restore the ownership of the multicast channel (procedure S1001).

[0095]

In this ownership restoration procedure S1001, the channel switching unit 1306 initially transmits the transfer message across the buses (procedure S804), and then the packet assembler 1304 formulates a transfer-of-channel-ownership message to restore the ownership of the multicast channel and broadcasts this message to all ports (procedure S1002). Then, the timer 1303 is activated to set up a time-out period for the reception of a reply message in response to the transmission of the ownership transfer message.

[0096]

Next, the following is a description of a sequence of events that occur when the bridge 507 restores the channel which has been assigned to the multicast group A1.

Following the notification of restoration of the channel ownership by the bridge 507 in procedure S1002, the timer 1303 runs out if no message that contains the bus 510 identifier, the destination address A1, the message type "report from source node" or "report from receive node", and the packet assembler 1304 formulates a transfer-of-channel-ownership message and sends it to the IRM node to restore the ownership of the assigned channel (procedure S1005). When the bridge 507 receives a message indicating the end of a channel ownership restoration procedure from the IRM node, the channel restoration routine is terminated. If the bridge 507 is the IRM node, no packet is formulated and the channel restoration is performed within the bridge 507 itself.

[0097]

In the embodiment 2 of the present invention, a channel is automatically acquired on the bus 510 even if it is located in the route of multicast packets between buses 509 and 511 so that the packets are not only transported on buses 509 and 511 where the member nodes of a multicast group are present and a channel is already acquired for the multicast group, but also transported over the bus 510. If no channel is assigned to a bus located in the route of a multicast transmission between two channel-assigned buses, the bridge on that bus automatically acquires the channel to allow passage of multicast packets.

Further, similar to the embodiment 1 of the present invention, if no multicast group member node exists on a bus and no multicast packets are routed through that bus, it is possible to use a network compliant with the IEEE 1394 standard on such a bus because on that bus no need exists to acquire a channel for multicast group and no packets are transported.

[0098]

<Embodiment 3>

The following is a description of a third embodiment of the present invention.

The packet transmission method and apparatus according to the embodiment 3 is to enable transmission of packets across buses where only

source nodes and receive nodes are attached.

The configuration of the network of this embodiment is identical to that shown in Fig. 1 and the format of the messages is also identical to the first embodiment. Therefore, the following description is only limited to those that differ from the embodiment 1.

[0099]

The following is a description of a packet communication method when multicast packet transmission is started, with reference to Fig. 8.

Fig. 8 illustrates a process in which a communication begins between a bus on which multicast group member nodes exist and a bus on which no multicast group member nodes exist. In this figure, parts corresponding to those in Fig. 3 of the first embodiment are marked with the same numerals. In the embodiment 3, the node 501 is supposed to send a multicast packet and the node 503 is supposed to receive the multicast packet over the buses directly connected to the bridge 507.

[0100]

In the same manner as the embodiment 1, the node 501 transmits an enquiry message for asking if a channel for the multicast group has already been acquired (procedure S701). The message transmitted in this procedure includes the bus 509 identifier and the node 501 identifier, the message type "enquiry", and the destination address "A1". If no reply message is received in response to this enquiry message, the node 501 initiates a channel acquisition procedure to acquire a channel C1 from the IRM node 502 (procedure S702).

[0101]

Node 501 then periodically broadcasts a channel mapping message representing the relationship between the multicast group and the acquired channel number (procedure S703). This message contains the bus 509 identifier, the node 501 identifier, the message type "report from source node", the channel number C1 and the destination address A1.

[0102]

On receiving the channel mapping message transmitted in procedure S703, each of the bridges examines the report from source node and stores the bus 509 identifier, the node 501 identifier, the message type "report from source node", the channel number C1, the destination address A1, the port A of bridge 507 on which this packet is received or the port A of the bridge 508 (procedure S704). Node 501 uses the acquired channel C1 to initiate transmission of

asynchronous stream packets (procedure S705).

[0103]

Node 503 on the bus 510 participates in the multicast group in order to receive multicast packets destined for this group (procedure S1101). Thereafter, the node 503 waits for periodically transmitted messages of the above mentioned process S703. Node 503, on receiving this message, examines the message and initiates a channel acquisition process if the message indicates that it is from buses other than the bus to which the node 503 is attached and its message type is "report from source node" and the destination address is A1 (procedure S1102).

[0104]

Simultaneously with the initiation of channel acquisition process (procedure S1102), the node 503 broadcasts an enquiry message asking if a multicast group channel is acquired on the bus 510 (procedure S1103). This message contains the bus 510 identifier, the node 503 identifier, the message type "enquiry", and the destination address A1. If no reply message is returned in response to the enquiry message, the node 503 initiates a channel acquisition routine to acquire a channel C2 from the IRM node 504 (procedure S1104).

[0105]

Following the execution of procedure S1104, the node 503 periodically broadcasts a channel mapping message to report the relationship between the channel identifier and the multicast group (procedure S1105). This message contains the bus 510 identifier, the node 503 identifier, the message type "report from receive node", the channel number C2, and the destination address A1.

[0106]

On receiving the message transmitted in the above mentioned procedure S1105, the bridge 507 examines the received message and extracts the bus 510 identifier, the node 503 identifier, the message type "report from receive node", the channel number C2, and the destination address A1 and the port number B of the bridge 507 on which this message was received, from the message and compares the message received earlier in procedure S703 at the opposite side port A of this bridge with the message transmitted to the node 503 in procedure S1105.

[0107]

If the destination addresses contained in compared message coincides

and their receive ports differ from each other, identification number 601 indicates that the messages are from buses directly connected to this bridge, the message types of both messages are not "report from receive node", the bridge 507 establishes a connection between the channels specified by the channel number 603 contained in this information (procedure S1106).

[0108]

Bridge 508 receives the message transmitted from the node 503 in procedure S1105, and compares the information stored in procedure S704 with the message transmitted in procedure S1105 in a manner similar to the node 507. Since the port numbers contained in these messages coincide, the bridge 508 does not establish inter-channel connection and stores the bus 510 identifier, the node 503 identifier, the message type "report from receive node", the channel number C2, the destination address A1 and the port number A of the bridge 508 on which this message was received (procedure S1107.

[0109]

Thereafter, asynchronous stream packets destined for address A1 are transmitted from the node 501 to the channel C1 and the bridge 507 transmits the asynchronous stream packets on channel C1 of the bus 509 to the channel C2 of the bus 510 (procedure S705). Node 503 receives these packets on bus 510.

In this way, multicast packet transmission from the source node 501 on bus 509 to the receive node 503 on bus 510 is performed via the bridge 507.

[0110]

The following is a description of a procedure which terminates the multicast session with reference to Fig. 9.

Fig. 9 shows that a communication proceeds from one bus to another via the bridge 507 and from this state the communication is terminated. In this figure, parts corresponding to those in Fig. 4 of the embodiment 1 are marked with the same reference numerals.

First, starting with the procedure shown in Fig. 8, the node 501 transmits a packet to the multicast group and the node 503 is receiving this packet. From this state, the node 501 stops sending packets (procedure S801). Following the multicast session termination, the node 501 broadcasts a transfer-of-channel-ownership message (procedure S802). This message includes the bus 509 identifier, the node 501 identifier, the message type "restoration of channel ownership", the channel number C1 and the destination address A1.

[0111]

On receiving the broadcast message of procedure S802, the bridge 507 examines this ownership-restoration message. If the bus identifier of this message coincides with the bus identifier of the bus to which the bridge 507 is directly connected, the bridge 507 stores the bus 509 identifier, the node 501 identifier, the channel number C1, and the destination address A1 (procedure S803). In like manner, when the bridge 508 receives the message broadcast in procedure S802, it examines the message. If the bus identifier of this message coincides with the bus identifier of the bus to which the bridge 508 is directly connected, the bridge 508 stores the bus 509 identifier, the node 501 identifier, , the channel number C1, and the destination address A1 (procedure S803).

[0112]

Following the execution of the above mentioned procedure S803, within the predetermined time interval Ta from the receipt of the transfer-of channel-ownership message, if the bridge 507 receives no message that contains the bus 509 identifier, the destination address A1 and the message type "report from source node", the bridge 507 clears off the connection between the buses 509 and 510 (procedure S804). Following the broadcast of the message according to the above mentioned procedure S802, and the channel is cleared off by the bridge 507 according to the procedure S804, the node 501 restores the channel C1 to the IRM node 502 (procedure S805).

Note that channel connection by a bridge is performed when packets are received on two different ports and the message types of these packets are other than "report from receive node". Since in the case of procedure S804, a packet whose message type is "report from receive node" is already received on one of the ports, the message type that triggers the bridge to perform channel connection is "report from source node" only. If such a packet is not received, the channel is cleared.

[0113]

Following the above mentioned procedure S803, within the predetermined time interval Tb (>Ta) from the receipt of the transfer-of channel-ownership message, if the bridge 503 receives no message that contains the bus 509 identifier, the destination address A1 and the message type "report from source node", meaning that there is no node within the bus 509 that takes over the channel ownership, the bridge 503 initiates a routine to release and restore the channel acquired for the bus 501 for the multicast session (procedure

S1201). The time interval Tb is set longer than the time interval Ta. The reason for this is to ensure that channel ownership transfer be effected after it is determined that there is no node on the bus 509 that takes over the channel ownership.

Note that the receive-only node that starts a channel acquisition routine is triggered to perform this routine in response to receipt of a message whose message type is "report from source node". Therefore, in the case of channel ownership restoration routine, the receive-only node is triggered to perform this routine only in response to receipt of a message whose message type is "report from source node".

[0114]

Simultaneously with the start of a channel release/restoration routine as described above in connection with procedure S1201, the node 503 broadcasts the transfer-of-channel-ownership message (procedure S1202). Within a predetermined time interval Tc following this event, the node 503 releases and restores the ownership of the channel acquired for the multicast group if it does not receive a message that contains the bus 510 identifier, the destination address A1, the message type "report from source node" or "report from receive node" (procedure S1203).

[0115]

The following is a detailed description of the structure and operation of the receive-only node 503 of the third embodiment.

Fig. 10 shows the configuration of the node 503. The receive-only node 503 is comprised of a memory 2102, a packet transceiver 2101, a timer 2103, a packet assembler 2104, and a packet analyzer 2105. Packets are transmitted and received through the packet transceiver 2101 to and from the bus 510. The function of each element of the node 503 is described below.

First, in procedure S703, when the node 503 received a message containing channel mapping information for multicast session, the node 503 forwards this packet to the packet analyzer 2105. If the bus identifier of this message indicates that it differs from the identifier of the bus to which the node 503 is attached, and the message type 602 of this message is "report from source node" and the destination address is A1, then the packet analyzer 2105 initiates a channel acquisition process for a multicast session (procedure S1102).

[0116]

Since the node 503 is responsible to determine, in procedure S1102,

whether a channel has already been acquired for the multicast group A1 in the bus to which the node 503 is directly connected, the packet assembler 2104 formulates and sends an enquiry message (procedure S1103). Further, the timer 2103 is activated to start a timing action.

[0117]

The following is a description of the operation of the node 503 when it acquires a channel for a multicast group. Following the transmission of the enquiry message in procedure S1103, if the node 503 receives no packet that contains no channel mapping information for the multicast group within the time-out period of the timer 2103, the packet assembler 2104 formulates a channel request packet and sends it to the IRM node 504 (procedure S1104). When a message is received from the IRM node, notifying that channel acquisition routine is terminated, the channel acquisition process is terminated. Note that if the node 503 is the IRM node, packet assemblage is not provided and channel acquisition is performed within the node 503.

[0118]

The following is a description of the operation of the node 503 when it transmits a report message containing channel mapping information following the execution of the channel acquisition routine. When the packet analyzer 2105 detects a channel acquisition message, the node 503 communicates this fact to the packet assembler 2104. In response, the packet assembler 2104 broadcasts the channel mapping information of the multicast group (procedure S1105). The packet analyzer 2105 instructs the packet transceiver 2101 to start receiving multicast data packets transmitted on the acquired channel.

[0119]

The following is a description of the operation of the node 503 when it receives the transfer-of-channel-ownership message for the multicast group in procedure S802. The transfer-of-channel-ownership message received from the node 501 is forwarded to the packet analyzer 2105 and examined. If the bus identifier of this message does not coincide with the identifier of the bus to which the node 503 is attached, the node 503 stores the bus 509 identifier and the node 501 identifier, the channel number C1 and the destination address A1 (procedure S803). Simultaneously, the timer 2103 is activated to begin a timing action to prepare a channel restoration routine.

[0120]

The following is a description of the operation of the node 503 when it

begins to return the channel ownership. In the above described procedure S802, following the receipt of the transfer-of-channel ownership message, if the node 503 does not receive a message that contains the bus 509 identifier, the destination address A1 and the message type "report from source node", the timer 2103 expires and the node 503 starts a channel restoration process (procedure S1201). During subsequent procedure S1202, the packet analyzer 2104 formulates a message for the restoration of channel ownership and transmits the message through the packet transceiver 2101. Following the transmission of this message from the node 503, the timer 2103 is activated and the node 503 waits for a message indicating the takeover of the channel ownership with the time-out period set by the timer 2103.

[0121]

The following is a description of the operation of the node 503 when it returns its channel ownership. During procedure S1202, following the transmission of the transfer-of-channel- ownership message, if the node 503 does not receive a message that contains the bus 510 identifier, the destination address A1 and the message type "report from source node" or "report from receive node", the timer 2103 expires and the packet assembler 2104 formulates a channel restoration packet and transmits it to the IRM node 504 (procedure S1208). On receiving the channel restoration packet from the IRM node, the node 503 commands the packet transceiver 2101 to stop receiving packets from the restored channel (procedure S2703), terminating the channel restoration process. Note that if the node 503 is the IRM node, packet restoration process is performed within the node 503 and hence no packet is formulated for this purpose.

[0122]

As described above, according to the embodiment 3, even if there is only one multicast group member node (as a receive-only node) within a single bus, this node automatically acquires a channel for multicast session, allowing the transmission of packets from a bus to which source nodes are attached to a bus to which receive nodes are only attached.

[0123]

While mention has been made of three embodiments, the present invention is not to be limited to these embodiments. Various modifications and different combinations of the embodiments are possible within the core of the present invention.

For example, in the previous embodiments, buses are connected in series via bridges. The present invention is not limited to this series configuration. For example, three or more bridges may be connected to a particular bus and to each of these buses may be connected a number of other buses in radial directions.

[0124]

[Advantageous Effects of the Invention]

As described above, according to the present invention, a plurality of buses are provided each including at least one node and being connected to each other via a plurality of bridges, and said bridges are connected between different buses and perform operation under a standardized serial bus communication protocol. When two or more nodes that are interconnected via said bridges communicate with each other within a shared multicast group, said bridges connect channels of said different buses, so that multicast packets can be transmitted via the bridges between multiple buses.

[0125]

According to a further aspect, the present invention provides a packet communication network comprising a plurality of buses each including at least one node and being connected to each other via a plurality of bridges, said buses and said bridges performing operation under a standardized serial bus communication protocol. Each of said nodes (a) that initiates a session on each of said buses is responsible for performing management of the channels to be used by its own multicast group for transmission of packets, and broadcasts a message identifying the relationship between multicast groups and said channels, and each of said bridges (b) is responsive to receipt of said message identifying the same bus for establishing a connection between different channels according to the received message. In this way, multicast packets can be transmitted via the bridges between multiple buses.

[0126]

According to a further aspect, the present invention provides a packet communications network comprising a plurality of buses each including at least one node and being connected to each other via a plurality of bridges, said buses and said bridges performing operation under a standardized serial bus communication protocol. Each of the nodes (a) that initiates a session on each of said buses is responsible for performing management of the channels to be used by its own multicast group for transmission of packets, and broadcasts a

message identifying said multicast group and said channels, and each of said bridges (b) that is connected to a bus where no node participates in said multicast group is responsive to receipt of a plurality of said messages identifying a same multicast group for reserving a channel in said bus where no node participates in said multicast group for a multicast session. In this way, even if there is a channel-unassigned bus in the route of packet transmission, multicast packet transmission is possible via the bridges between different buses.

[0127]

According to a still further aspect, the present invention provides a packet communication network comprising a plurality of buses each including at least one node and being connected to each other via a plurality of bridges, said buses and said bridges performing operation under a standardized serial bus communication protocol. (a) Each of said buses that initiates a session on each of said buses is responsible for performing management of the channels to be used by its own multicast group for transmission of packets, and broadcasts a message identifying said multicast group and said channels. (b) Each of said nodes that exclusively perform packet reception on each of said buses is responsible for performing management of channels to be used for receiving packets from multicast groups if there is no node within the same bus that performs channel management and broadcasts a message identifying said multicast group and said channels. (c) Each of said bridges is responsive to receipt of said message identifying the same bus for establishing a connection between different channels according to the received message. As a result, even if there is only receive node on a bus in the route of packet transmission, multicast packets can be transmitted over the bridges between different buses.

[BRIEF DESCRIPTION OF THE DRAWINGS]

[Fig. 1] A block diagram of a communications network according to a first embodiment of the present invention.

[Fig. 2] An illustration of the data format used in the first embodiment of the present invention.

[Fig. 3] A sequence diagram for starting a packet communication according to the first embodiment of the present invention.

[Fig. 4] A sequence diagram for terminating a packet communication according to the first embodiment of the present invention.

[Fig. 5] A block diagram of a bridge of the first embodiment of the

present invention.

[Fig. 6] A sequence diagram of starting a packet communication according to a second embodiment of the present invention.

[Fig. 7] A sequence diagram for terminating a packet communication according to the second embodiment of the present invention.

[Fig. 8] A sequence diagram of starting a packet communication according to a third embodiment of the present invention.

[Fig. 9] A block diagram of a communications network according to a first embodiment of the present invention.

[Fig. 10] A sequence diagram for terminating a packet communication according to the third embodiment of the present invention.

[Fig. 11] A block diagram of a prior art communications network.

[Fig. 12] A sequence diagram of the prior art communications network for acquiring a channel.

[Fig. 13] A sequence diagram of the prior art communications network for restoring the acquired channel.

[Fig. 14] A block diagram of a communications network using bridges for interconnecting buses.

[EXPLANATION OF REFERENCE NUMERALS]

501 ~ 506	nodes
507, 508	bridges
509 ~ 511	buses
601	node identification number
602	message type
603	channel number
604	destination address
S701	multicast group channel availability enquiry procedure
S702	multicast group channel acquisition procedure
S703	reporting procedure for notifying channel mapping information
S704	storing procedure for reporting message from source node
S705	data transmission procedure for multicast group
S706	multicast group channel availability enquiry procedure
S707	multicast group channel acquisition procedure
S708	reporting procedure for notifying channel mapping information
S709	storing procedure for reporting message from source node
S710	inter-channel connection procedure

S711	data transmission procedure for multicast group
S801	multicast session termination procedure
S802	notification procedure for communicating channel restoration
S803	storing procedure for channel restoration notifying message
S804	channel clear-down procedure
S805	multicast channel restoration procedure
S901	multicast group channel availability enquiry procedure
S902	multicast group channel acquisition procedure
S903	reporting procedure for notifying channel mapping information
S904	storing procedure for reporting message from source node
S905	multicast group channel availability enquiry procedure
S906	multicast group channel availability enquiry procedure
S907	multicast group channel acquisition procedure
S908	reporting procedure for notifying channel mapping information
S909	inter-channel connection procedure
S910	data transmission procedure for multicast group
S911	data transmission procedure for multicast group
S1001	multicast group channel restoration starting procedure
S1002	multicast group channel restoration notification procedure
S1003	multicast group channel availability enquiry procedure
S1004	multicast group channel acquisition procedure
S1005	reporting procedure for notifying channel mapping information
S1006	inter-channel connection procedure
S1007	storing procedure for reporting message from source node
S1201	multicast group channel restoration starting procedure
S1202	multicast group channel restoration notification procedure
S1203	multicast group channel availability enquiry procedure
1301	bridge
1302	memory
1303	packet assembler
1305	packet analyzer
1306	packet switching unit
2101	packet transceiver
2102	memory
2103	timer
2104	packet assembler
2105	packet analyzer

[Title of the Document] SUMMARY

[SUMMARY]

[Object]

To provide a packet communication method and system for transmitting multicast packets between different buses over bridges.

[Means for Solution]

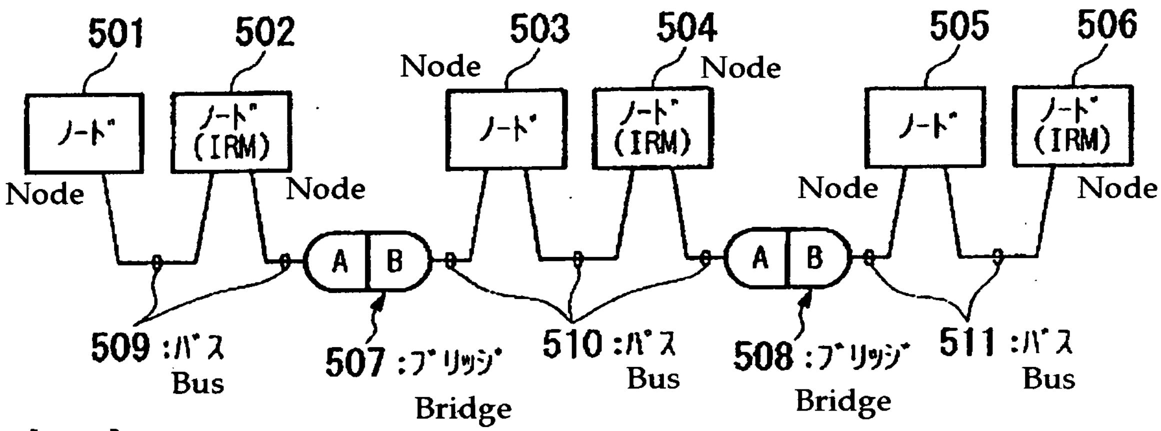
In a packet communication network, a bridge 507 is connected between buses 509 and 510 to which nodes 501 and 503 are respectively attached. When each of the nodes 501 and 503 sends a packet for a multicast group, each node acquires a channel from a predetermined management node and establishes itself as a management node. Each of the nodes 501 and 503 broadcasts a channel mapping notification message at periodic intervals. On receiving packets from the buses 509 and 510, the bridge 507 correlates the received packets according to the channel mapping information to transmit the packets.

[Selected Drawing]

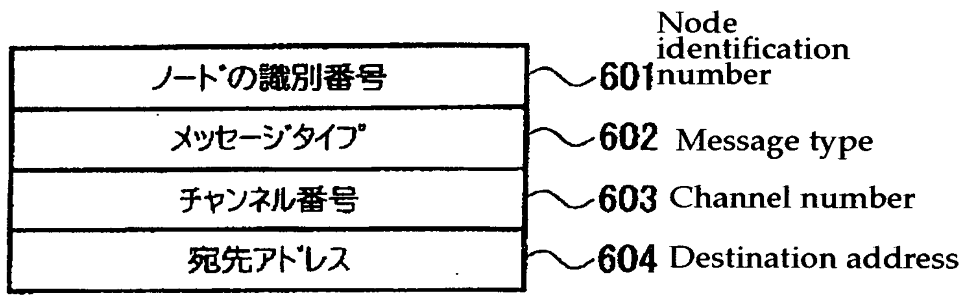
Fig. 1

【書類名】　図面

【図1】 Fig. 1



【図2】
Fig. 2

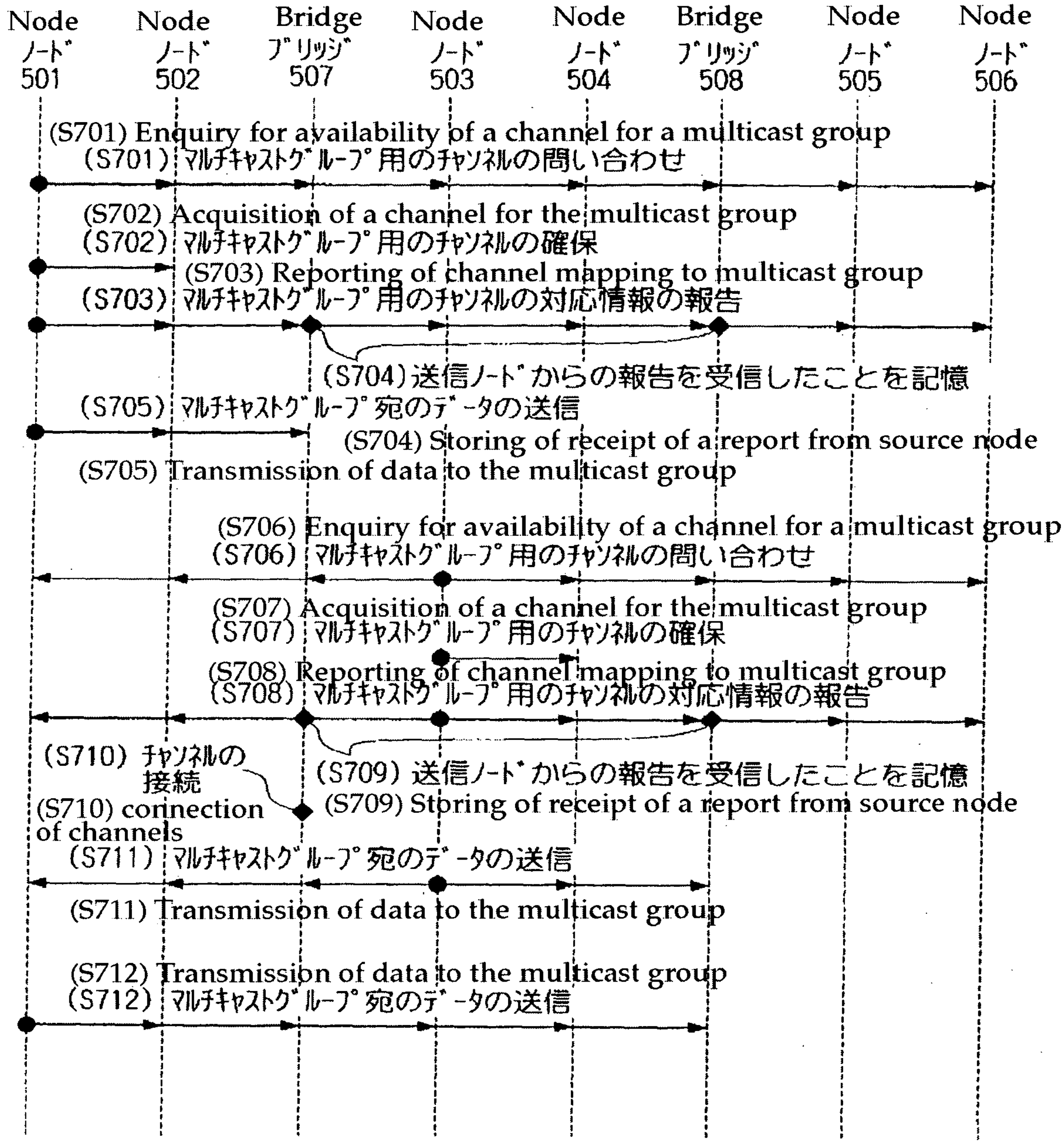


【図３】

Fig. 3

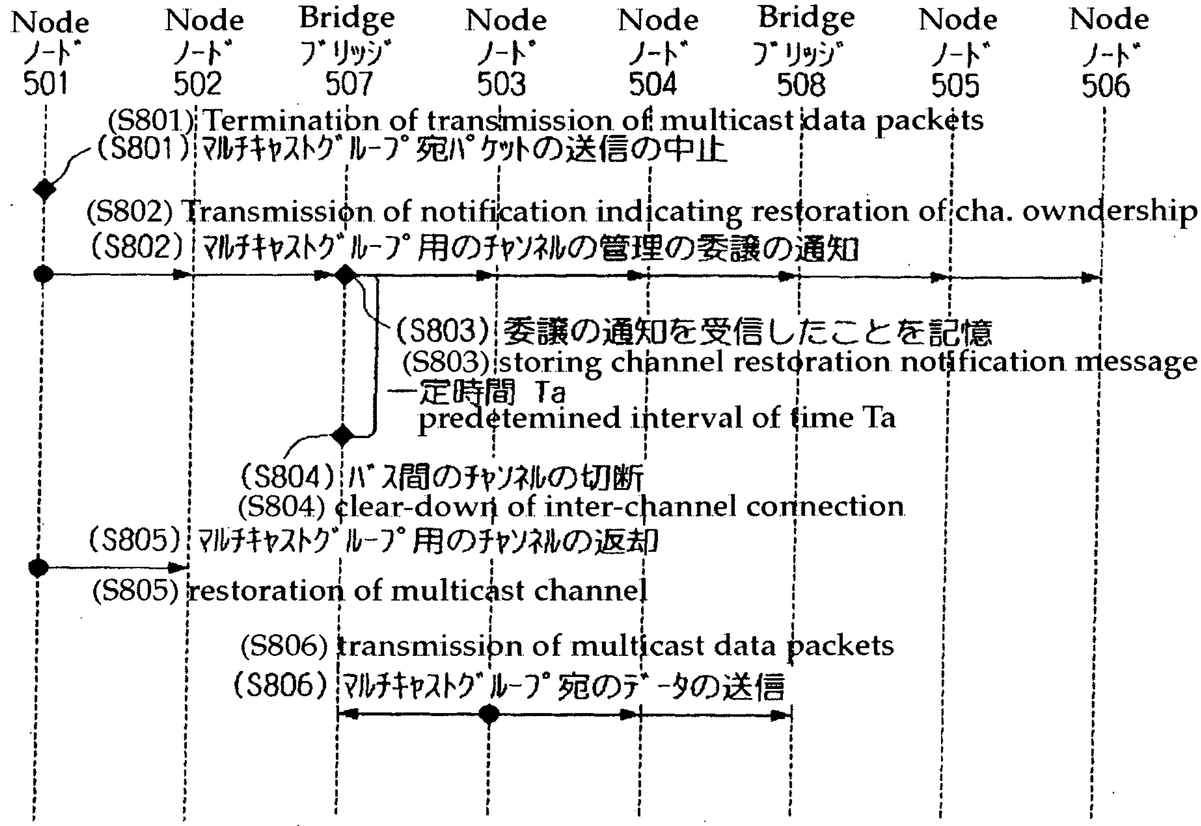
(Procedures for starting a multicast session)

〈マルチキャストによる通信を開始する場合の手順〉



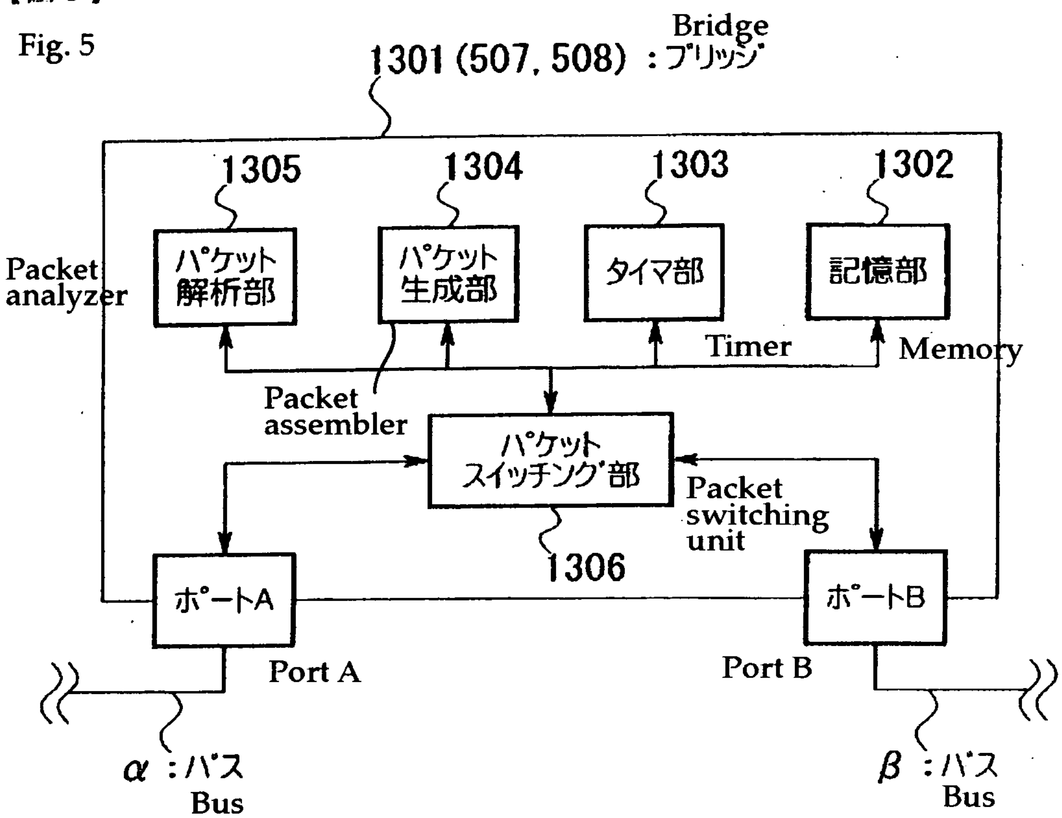
【図４】
Fig. 4

(Procedures for terminating a multicast session)
〈マルチキャストによる通信を停止する場合の手順〉



【図５】

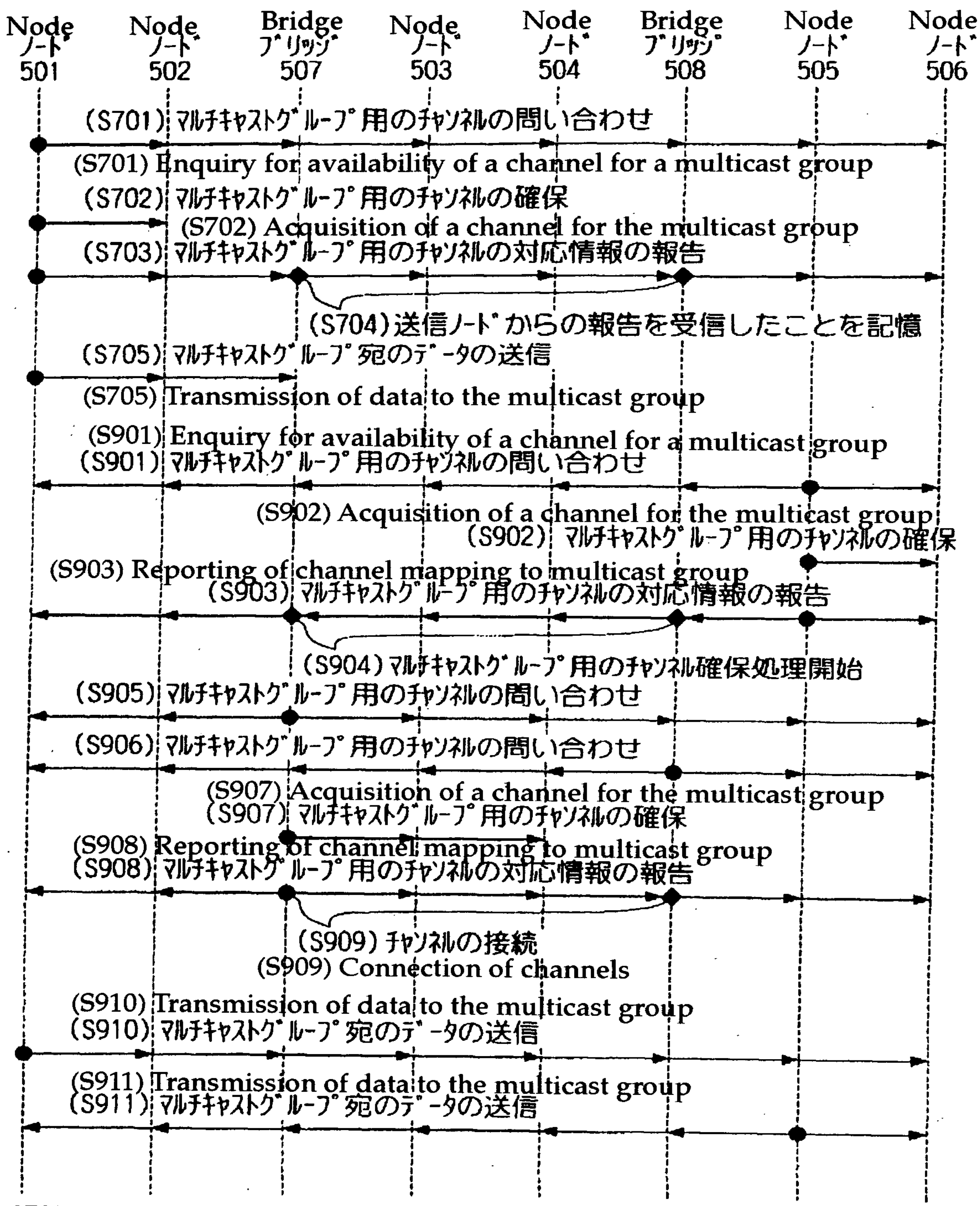
Fig. 5


Bridge
1301 (507, 508) ：ブリッジ
1305
1304
1303
1302
Packet analyzer
パケット解析部
パケット生成部
タイマ部
記憶部
Timer
Memory
Packet assembler
パケットスイッチング部
Packet switching unit
1306
ポートA
ポートB
Port A
Port B
α ：バス
Bus
β ：バス
Bus

【図６】

Fig. 6

(Procedures for starting a multicast session)
〈マルチキャストによる通信を開始する場合の手順〉



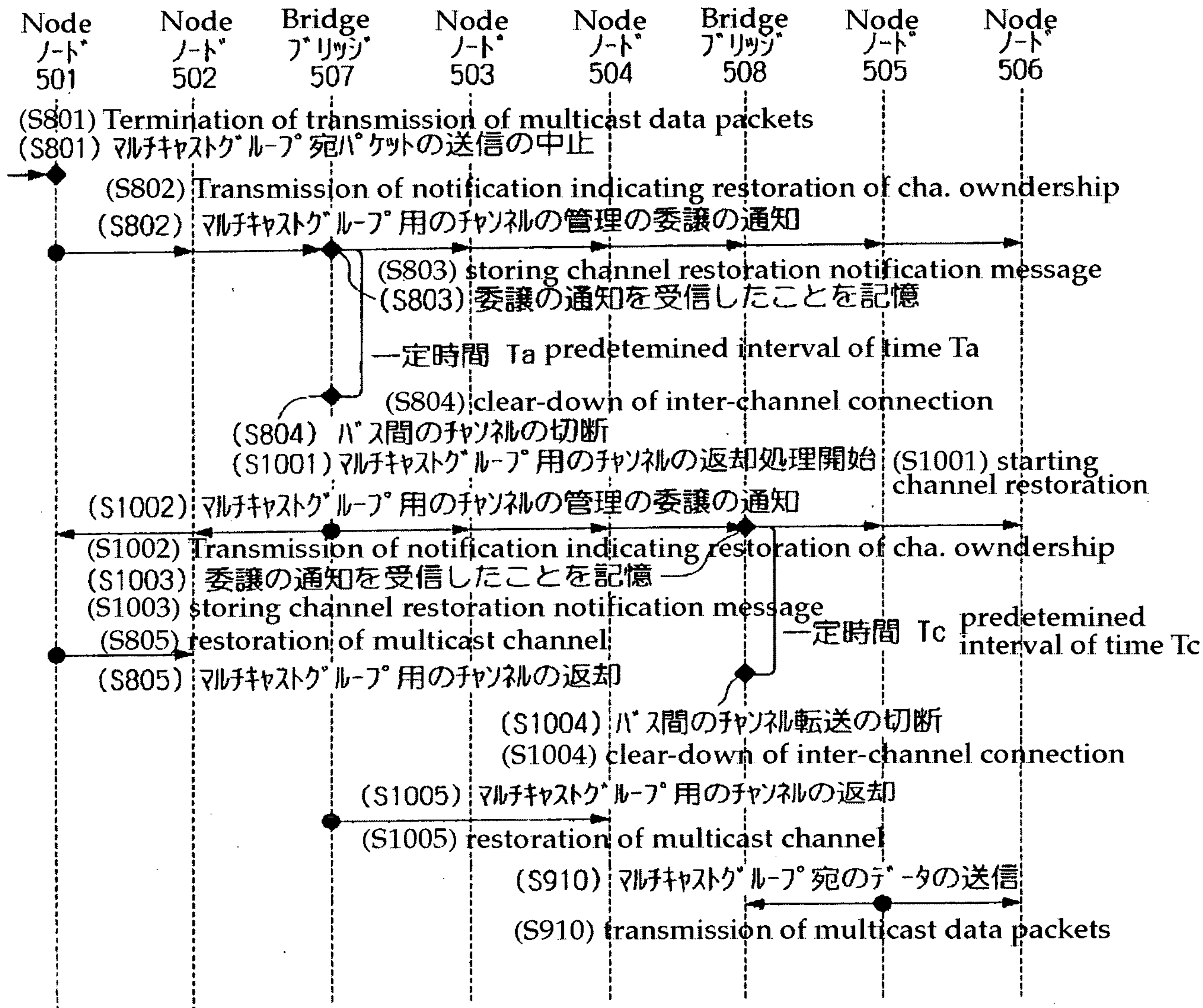
(S703) Reporting of channel mapping to multicast group
(S704) Storing of receipt of a report from source node
(S904) Start of channel acquisition for multicast group
(S905) (S906) Enquiry for availability of a channel for a multicast group

【図７】

Fig. 7

(Procedures for terminating a multicast session)

〈マルチキャストによる通信を停止する場合の手順〉

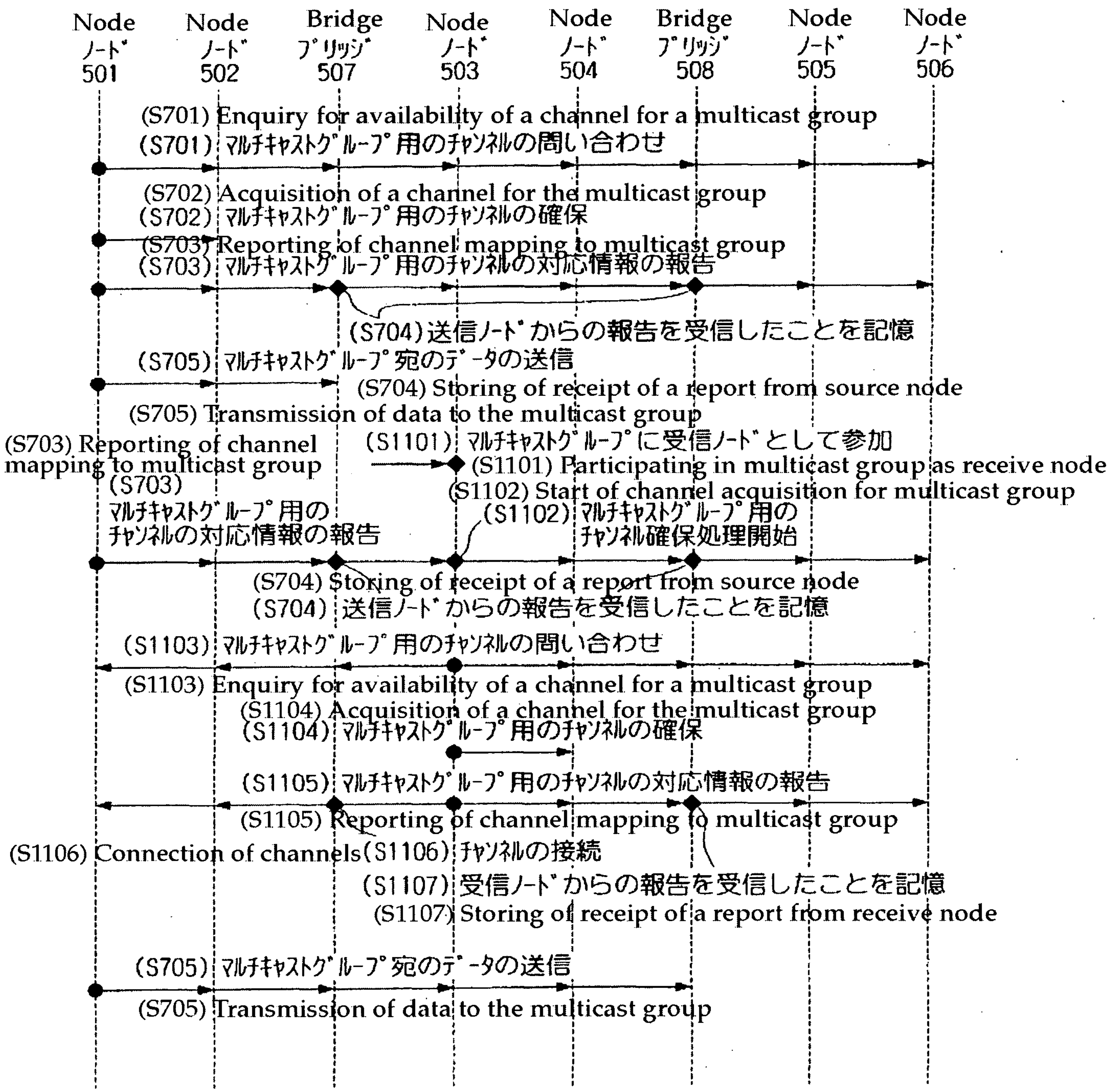


【図８】

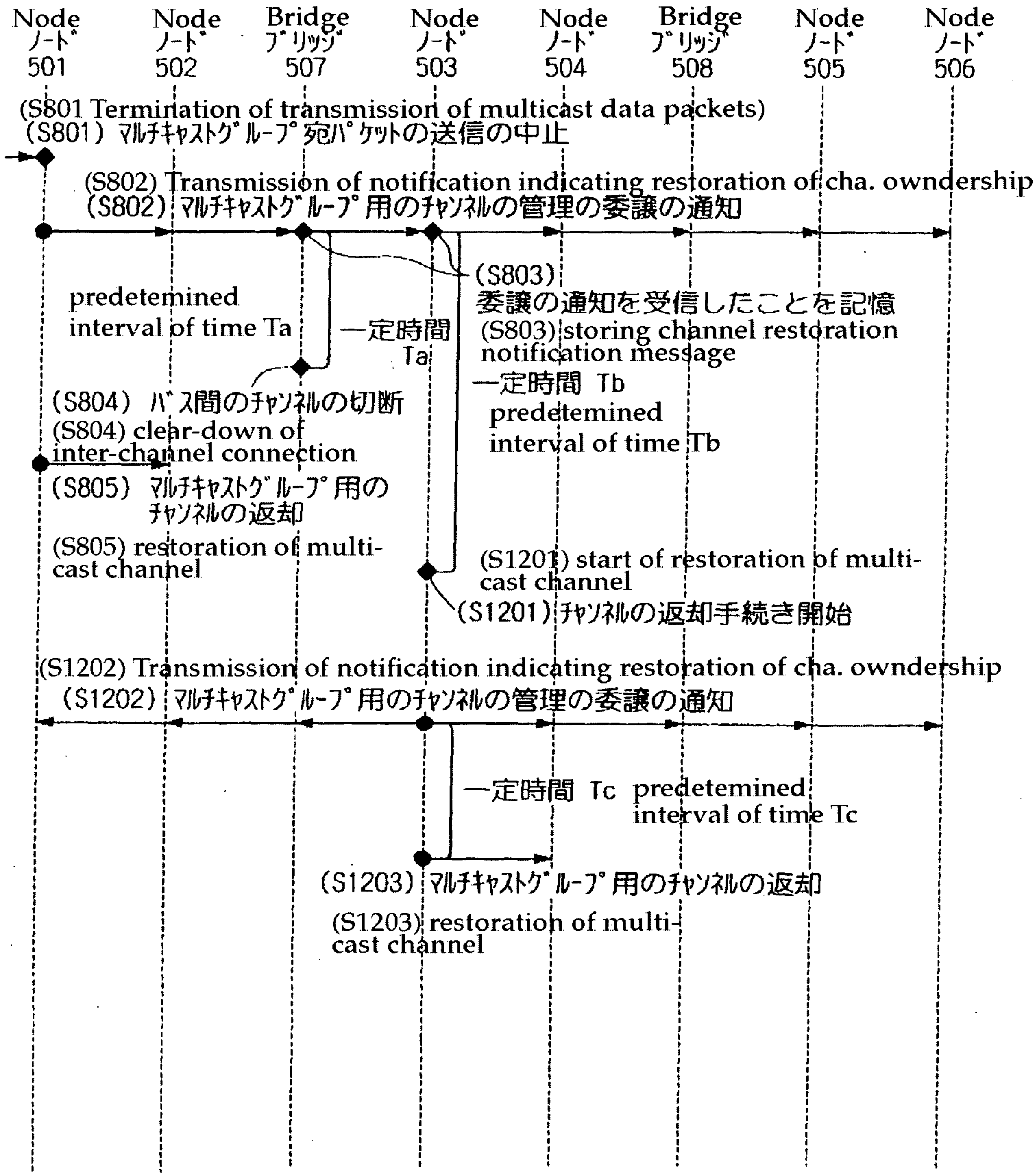
Fig. 8

(Procedures for starting a multicast session)

〈ﾏﾙﾁｷｬｽﾄによる通信を開始する場合の手順〉

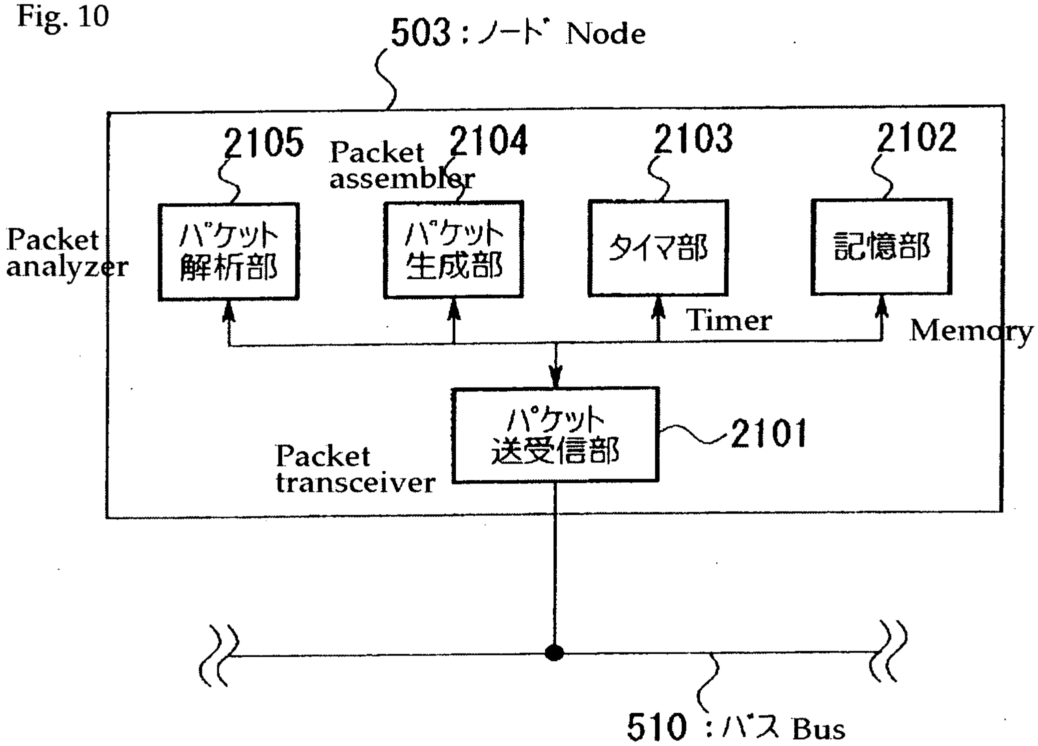


【図９】
Fig. 9　(Procedures for terminating a multicast session)
〈マルチキャストによる通信を停止する場合の手順〉



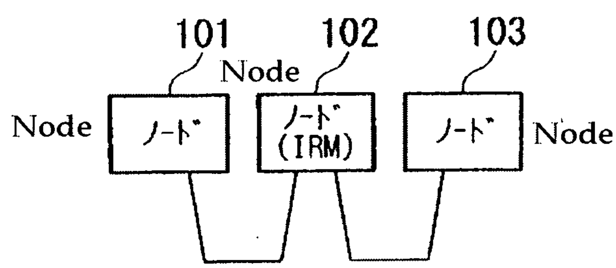
【図１０】

Fig. 10

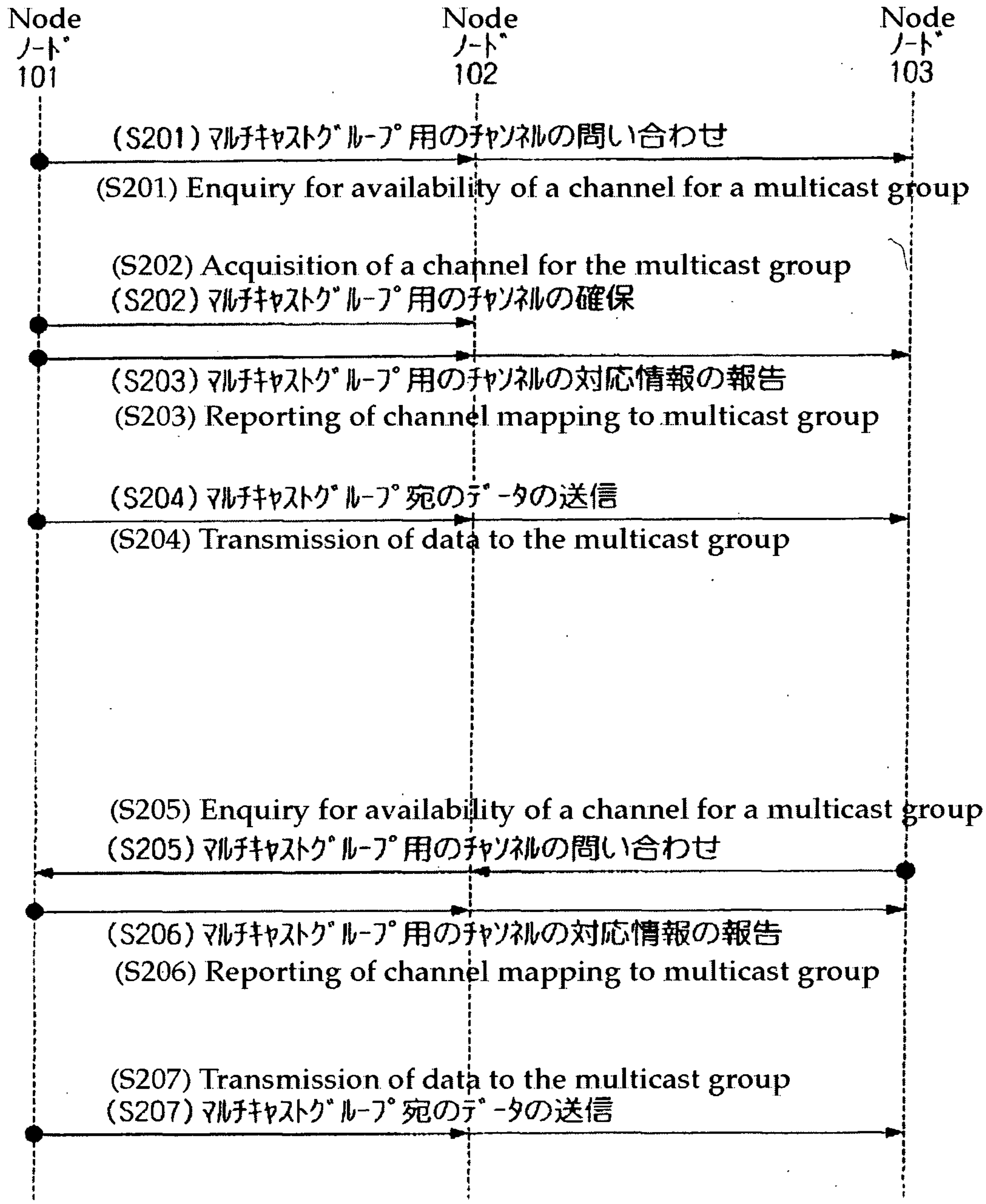


【図１１】

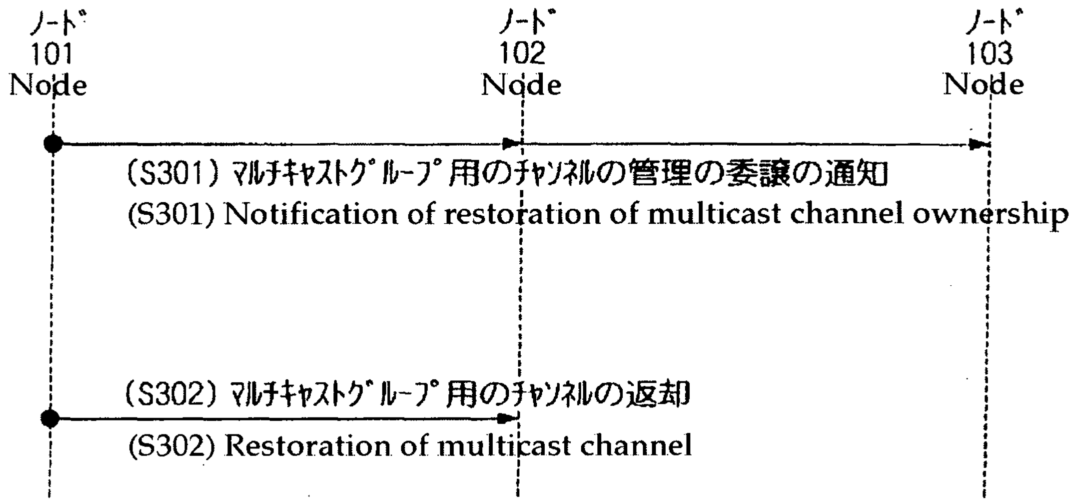
Fig. 11



【図１２】Fig. 12


Node
ノード
101
Node
ノード
102
Node
ノード
103
(S201) マルチキャストグループ用のチャンネルの問い合わせ
(S201) Enquiry for availability of a channel for a multicast group
(S202) Acquisition of a channel for the multicast group
(S202) マルチキャストグループ用のチャンネルの確保
(S203) マルチキャストグループ用のチャンネルの対応情報の報告
(S203) Reporting of channel mapping to multicast group
(S204) マルチキャストグループ宛のデータの送信
(S204) Transmission of data to the multicast group
(S205) Enquiry for availability of a channel for a multicast group
(S205) マルチキャストグループ用のチャンネルの問い合わせ
(S206) マルチキャストグループ用のチャンネルの対応情報の報告
(S206) Reporting of channel mapping to multicast group
(S207) Transmission of data to the multicast group
(S207) マルチキャストグループ宛のデータの送信

【図１３】Fig. 13



【図１４】Fig. 14